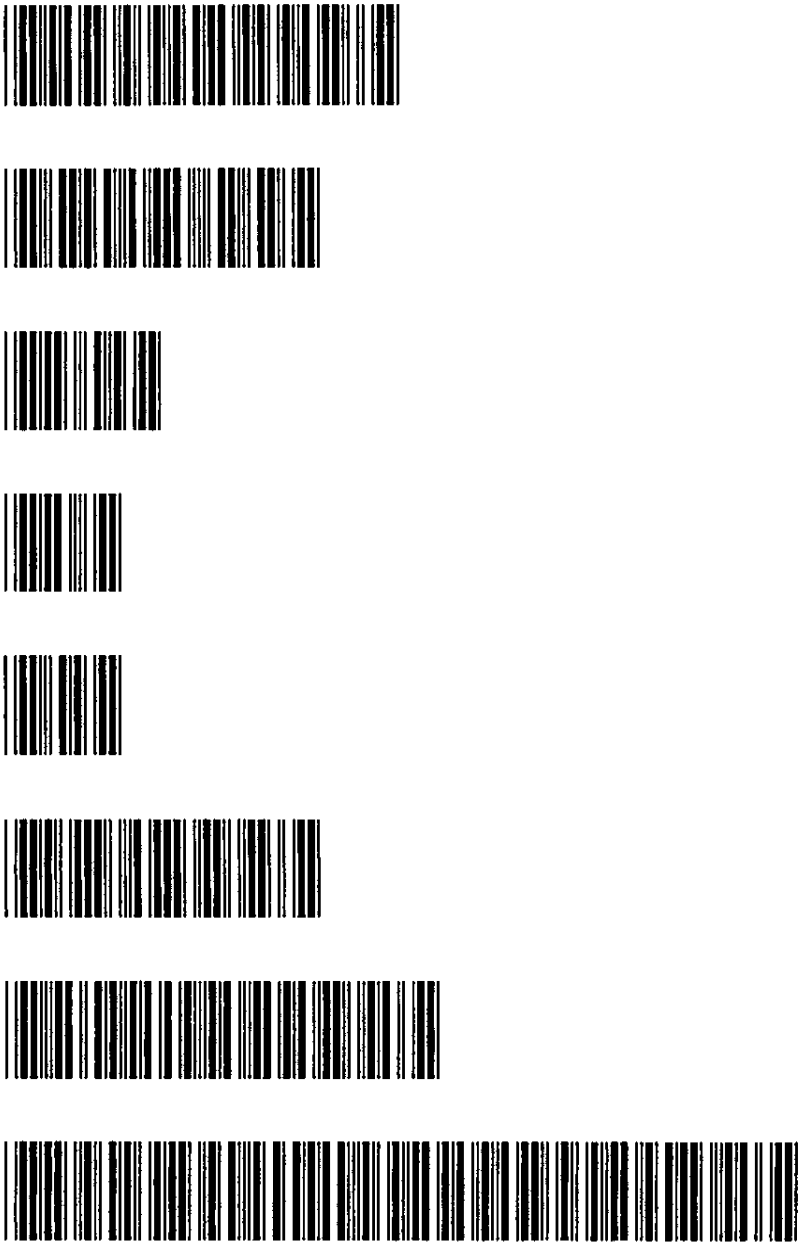
USDC SCAN INDEX SHEET



CAG 1/23/06 15:04

3:05-CV-02300 T SYSTEMS V. CHAPIN WATERMATICS

4

AMDCMP.

ORIGINAL

FILED
JAN 20 2006
CLERK, U.S. DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA
BY

GARY DUKARICH, CA Bar No. 188561
E-Mail: gsd@cph.com
JOEL A. KAUTH, CA Bar No. 186544
E-Mail: jak@cph.com
CHRISTIE, PARKER & HALE, LLP
3501 Jamboree Road
North Tower, Suite 6000
Newport Beach, CA 92660-2960
Telephone: (949) 476-0757
Facsimile: (949) 476-8640

Attorneys for Plaintiff
T-SYSTEMS INTERNATIONAL, INC.

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

BY FAX

T-SYSTEMS INTERNATIONAL, INC., Plaintiff, vs. CHAPIN WATERMATICS, INC., a New York corporation, and WILLIAM CHAPIN, an individual. Defendants.	Case No. 05-CV-02300 DMS(AJB) **FIRST AMENDED COMPLAINT FOR INJUNCTION AND DAMAGES (PATENT INFRINGEMENT)** **DEMAND FOR JURY TRIAL** **Hon. Dana M. Sabraw**

For its first amended complaint, Plaintiff T-Systems International, Inc. ("T-Systems") alleges as follows:

JURISDICTION.

1. This is an action for patent infringement in violation of 35 U.S.C. Section 271. This Court has jurisdiction pursuant to 15 U.S.C. Section 1121 and 28 U.S.C. Section 1338(a), (b).

2. Venue is proper under 28 U.S.C. Sections 1391(b), (c) and 1400(b).

4

PARTIES.

3. Plaintiff T-Systems is a corporation organized and existing under the laws of the State of California, having a principal place of business at 7545 Carroll Road, San Diego, California 92121.

4. Plaintiff is informed and believes, and thereon alleges that Defendant Chapin Watermatics, Inc. is a corporation organized and existing under the laws of the State of New York, having a principal place of business at 740 Water Street, Watertown, New York 13601.

4. Plaintiff is informed and believes, and thereon alleges that Defendant William Chapin is the president of Chapin Watermatics, Inc.

FACTUAL BACKGROUND.

5. T-Systems is a manufacturer and distributor of irrigation hose.

6. On July 19, 1994, an application was filed with the United States Patent and Trademark Office ("PTO") to obtain a patent on a drip irrigation hose and method and apparatus for its manufacture. The application was filed in the name of inventors Michael DeFrank, David Marchetti and David L. Teegardin and subsequently assigned to T-Systems. U.S. Patent Number 5,522,551 (the "'551 Patent"), entitled "Drip Irrigation Hose and Method for its Manufacture," issued on that application on June 4, 1996. A copy of the '551 Patent is attached hereto as Exhibit A. T-Systems has owned all right, title and interest in the '551 Patent since the date of its issuance.

7. On May 20, 1996, an application was filed with the United States

Patent and Trademark Office ("PTO") to obtain a patent on a drip irrigation hose and method and apparatus for its manufacture. The application was filed in the name of inventors Michael DeFrank, David Marchetti and David L. Teegardin and subsequently assigned to T-Systems. U.S. Patent Number 5,634,595 (the "'595 Patent"), entitled "Drip Irrigation Hose and Method for its Manufacture," issued on that application on June 3, 1997. A copy of the '595 Patent is attached hereto as Exhibit B. The '595 Patent is a direct continuation of the application that led to the '551 Patent and is thus entitled to priority from the filing date of that prior application, July 19, 1994. T-Systems has owned all right, title and interest in the '595 Patent since the date of its issuance.

8. On May 2, 1997, an application was filed with the United States Patent and Trademark Office ("PTO") to obtain a patent on a drip irrigation hose and method and apparatus for its manufacture. The application was filed in the name of inventors Michael DeFrank, David Marchetti and David L. Teegardin and subsequently assigned to T-Systems. U.S. Patent Number 5,865,377 (the "'377 Patent"), entitled "Drip Irrigation Hose and Method for its Manufacture," issued on that application on February 2, 1999. A copy of the '377 Patent is attached hereto as Exhibit C. The '377 Patent is an indirect continuation of the application that led to the '551 Patent and is thus entitled to priority from the filing date of that prior application, July 19, 1994. T-Systems has owned all right, title and interest in the '377 Patent since the date of its issuance.

9. On August 4, 1998, an application was filed with the United States Patent and Trademark Office ("PTO") to obtain a patent on a method and

apparatus for making a drip irrigation hose. The application was filed in the name of inventors Michael DeFrank, David Marchetti and David L. Teegardin and subsequently assigned to T-Systems. U.S. Patent Number 6,464,816 (the "'816 Patent"), entitled "Method and Apparatus for Making a Drip Irrigation Hose," issued on that application on October 15, 2002. A copy of the '816 Patent is attached hereto as Exhibit D. The '816 Patent is an indirect continuation of the application that led to the '551 Patent and is thus entitled to priority from the filing date of that prior application, July 19, 1994. T-Systems has owned all right, title and interest in the '816 Patent since the date of its issuance.

10. On July 11, 2002, an application was filed with the United States Patent and Trademark Office ("PTO") to obtain a patent on a method for making a drip irrigation hose. The application was filed in the name of inventors Michael DeFrank, David Marchetti and David L. Teegardin and subsequently assigned to T-Systems. U.S. Patent Number 6,936,126 (the "'126 Patent"), entitled "Method of Manufacture of a Drip Irrigation Hose," issued on that application on August 30, 2005. A copy of the '126 Patent is attached hereto as Exhibit E. The '126 Patent is an indirect continuation of the application that led to the '551 Patent and is thus entitled to priority from that filing date of that prior application, July 19, 1994. T-Systems has owned all right, title and interest in the '126 Patent since the date of its issuance.

11. Defendant Chapin Watermatics, Inc. has imported or made and offered for sale and sold, and continues to import or make and to offer for sale and sell, drip irrigation hose (the "Chapin Hose") covered by one or more claims

of the '551 Patent, '595 Patent, and '337 Patent, without the consent or authorization of T-Systems.

12. T-Systems is informed and believes, and thereon alleges that Defendant Chapin Watermatics, Inc., in the course of manufacturing the Chapin Hose, has practiced methods and processes, and continues to practice methods and processes, covered by one or more claims of the '551 Patent, '595 Patent, '816 Patent, and '126 Patent, without the consent or authorization of T-Systems.

13. T-Systems is informed and believes, and thereon alleges that Defendant Chapin Watermatics, Inc., in the course of manufacturing the Chapin Hose, has imported or made and has used an apparatus covered by one or more claims of the '551 Patent, '595 Patent, and '816 Patent, without the consent or authorization of T-Systems.

14. T-Systems is informed and believes, and thereon alleges that all the aforementioned acts of Defendant Chapin Watermatics, Inc., were undertaken at the express direction of Defendant William Chapin, who acted with willful malice toward, and wanton disregard of, T-Systems' patent rights.

FIRST CLAIM FOR RELIEF

Patent Infringement

15. T-Systems hereby repeats and realleges paragraphs 1 through 14 hereinabove as though fully set forth herein.

16. Defendants, by themselves or in concert with others, have imported, made, used, sold or offered to sell, and continue to import, make, use, sell or offer

to sell, in this district and elsewhere in the United States, drip irrigation hose that infringes the '551 Patent, '595 Patent, and '337 Patent.

17. T-Systems is informed and believes, and thereon alleges that Defendants, by themselves or in concert with others, have imported, made, used, sold or offered to sell, and continue to import, make, use, sell or offer to sell, in this district and elsewhere in the United States, drip irrigation hose manufactured through the use of methods and processes that infringe the '551 Patent, '595 Patent, '816 Patent, and '126 Patent.

18. T-Systems is informed and believes, and thereon alleges that Defendants, by themselves or in concert with others, have imported, made, or used, and continue to import, make, or use, within the United States, a drip irrigation hose manufacturing apparatus that infringes the '551 Patent, '595 Patent, and '816 Patent.

19. The aforesaid acts of Defendants are without right, license, or authorization from T-Systems.

20. By its aforesaid acts, Defendants have violated 35 U.S.C. Section 271 by its infringement of the '551 Patent, '595 Patent, '337 Patent, '816 Patent, and '126 Patent (collectively, the "T-Systems Patents").

21. T-Systems is informed and believes, and thereon alleges that the acts of infringement by Defendants will continue unless enjoined by this Court.

/////

/////

/////

22. T-Systems is being damaged by Defendants' infringement of the T-Systems Patents and is being and will continue to be irreparably damaged unless the infringement is enjoined by this Court.

23. T-Systems is informed and believes, and thereon alleges that Defendants have had actual notice of the existence of the T-Systems Patents, and despite such notice have continued to engage in acts of infringement.

24. T-Systems is informed and believes, and thereon alleges that Defendants' infringement of the T-Systems Patents is and has been willful and T-Systems is entitled to enhanced damages against Defendants.

25. This is an exceptional case and T-Systems is entitled to an award of its attorneys' fees pursuant to 35 U.S.C. Section 285.

WHEREFORE, Plaintiff T-Systems demands judgment against Defendants as follows:

1. For a preliminary and permanent injunction prohibiting Defendants from further infringing the T-Systems Patents;

2. For patent infringement damages in an amount not less than a reasonable royalty pursuant to 35 U.S.C. Section 284, and for these damages to be trebled;

3. For prejudgment interest on all infringement damages;

4. For costs of this Action, including attorneys' fees; and

/////

/////

5. For such other or further relief as the Court may deem just and proper.

DATED: January 20, 2006

Respectfully submitted,

CHRISTIE, PARKER & HALE, LLP

By _____
Gary Dukarich
Joel A. Kauth
Attorneys for Plaintiff
T-SYSTEMS INTERNATIONAL, INC.

DEMAND FOR JURY TRIAL

Plaintiff T-Systems International, Inc. hereby demands, pursuant to Federal Rule of Civil Procedure 38(b), a trial by jury of all issues so triable.

DATED: January 20, 2006

Respectfully submitted,

CHRISTIE, PARKER & HALE, LLP

By _____
Gary Dukarich
Joel A. Kauth
Attorneys for Plaintiff
T-SYSTEMS INTERNATIONAL, INC.

RAK IRV1092013.3-*-01/20/06 9:39 AM

Exhibit A

US005522551A

United States Patent [19]

DeFrank et al.

[11] Patent Number: 5,522,551

[45] Date of Patent: Jun. 4, 1996

[54] **DRIP IRRIGATION HOSE AND METHOD FOR ITS MANUFACTURE**

[75] Inventors: Michael DeFrank, Temecula; David Marchetti; David L. Teegardin, both of San Diego, all of Calif.

[73] Assignee: T-Systems International, Inc., San Diego, Calif.

[21] Appl. No.: 279,813

[22] Filed: Jul. 19, 1994

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 67,382, May 26, 1993, abandoned.

[51] Int. Cl.[6] B05B 15/00; B29C 53/48

[52] U.S. Cl. 239/542; 156/203; 156/252; 156/466; 156/513; 239/533.13

[58] Field of Search ..... 239/107, 533.1, 239/533.13, 533.15, 542, 562, 566, 568, 602, DIG. 12; 156/201, 202, 203, 252, 465, 466, 513

[56] References Cited

U.S. PATENT DOCUMENTS

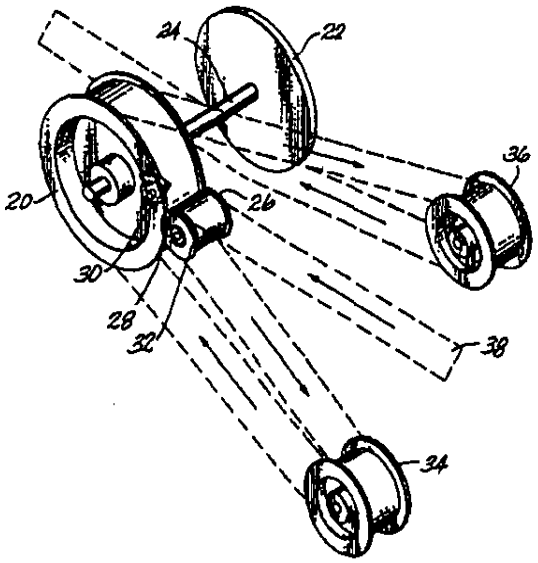
4,247,051	1/1981	Allport	239/542
4,548,360	10/1985	Delmer et al.	239/542
4,642,152	2/1987	Chapin	156/203
4,850,947	7/1989	Brown et al.	156/252 X
4,984,739	1/1991	Allport	239/542 X
5,123,984	6/1992	Allport et al.	239/542 X
5,375,770	12/1994	Roberts	239/568

Primary Examiner—Andres Kashnikow
Attorney, Agent, or Firm—Christie, Parker & Hale

[57] **ABSTRACT**

A drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized. An outlet forming wheel has a knife blade on its periphery. A backing wheel engages the outlet forming wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. The outlet forming wheel and the rib forming wheel are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in a path that reverses direction four times to accommodate these wheels.

4 Claims, 4 Drawing Sheets



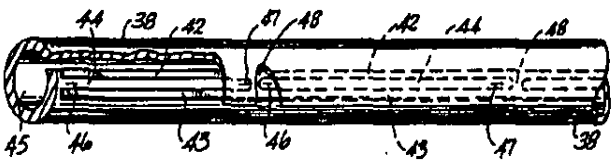


Exhibit: A

Page: 10

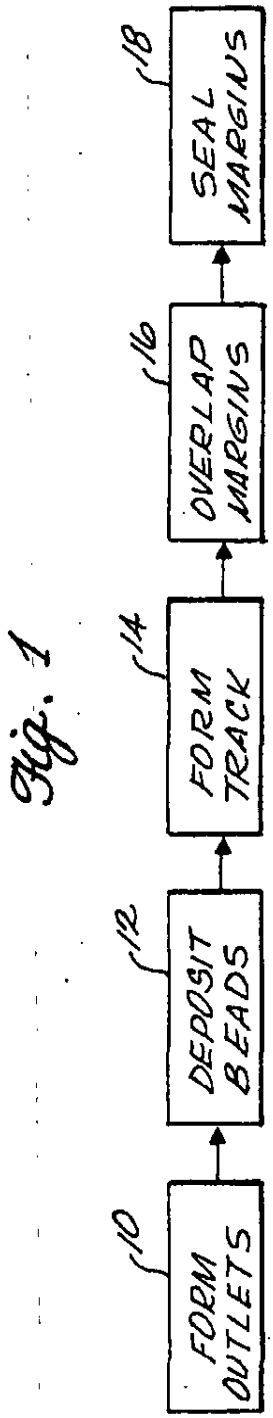


Fig. 1

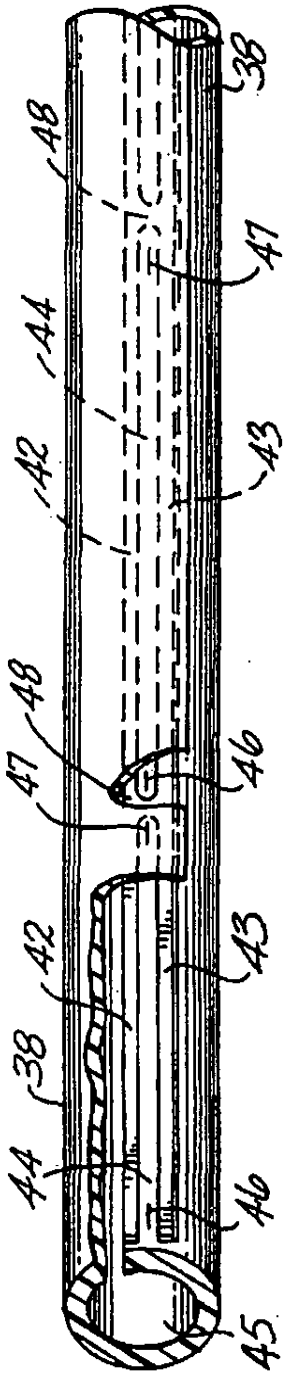


Fig. 4

Exhibit: A

Page: 11

Fig. 2

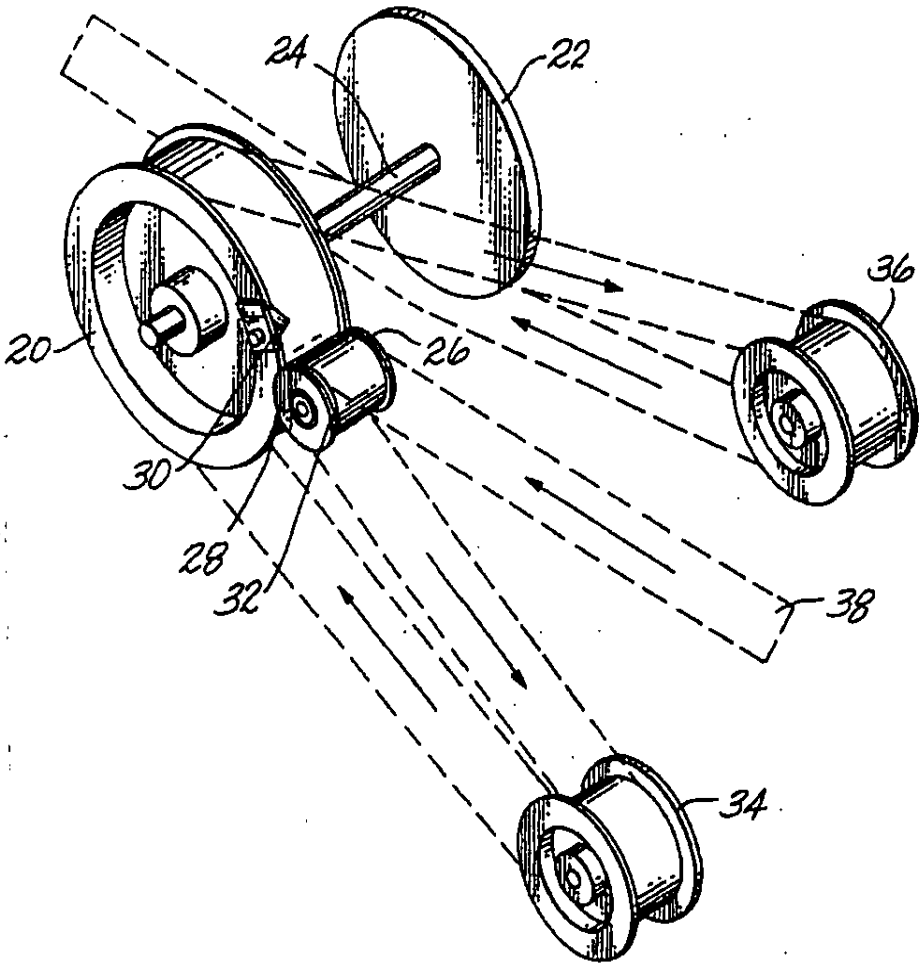


Exhibit: A

Page: 12

Fig. 3

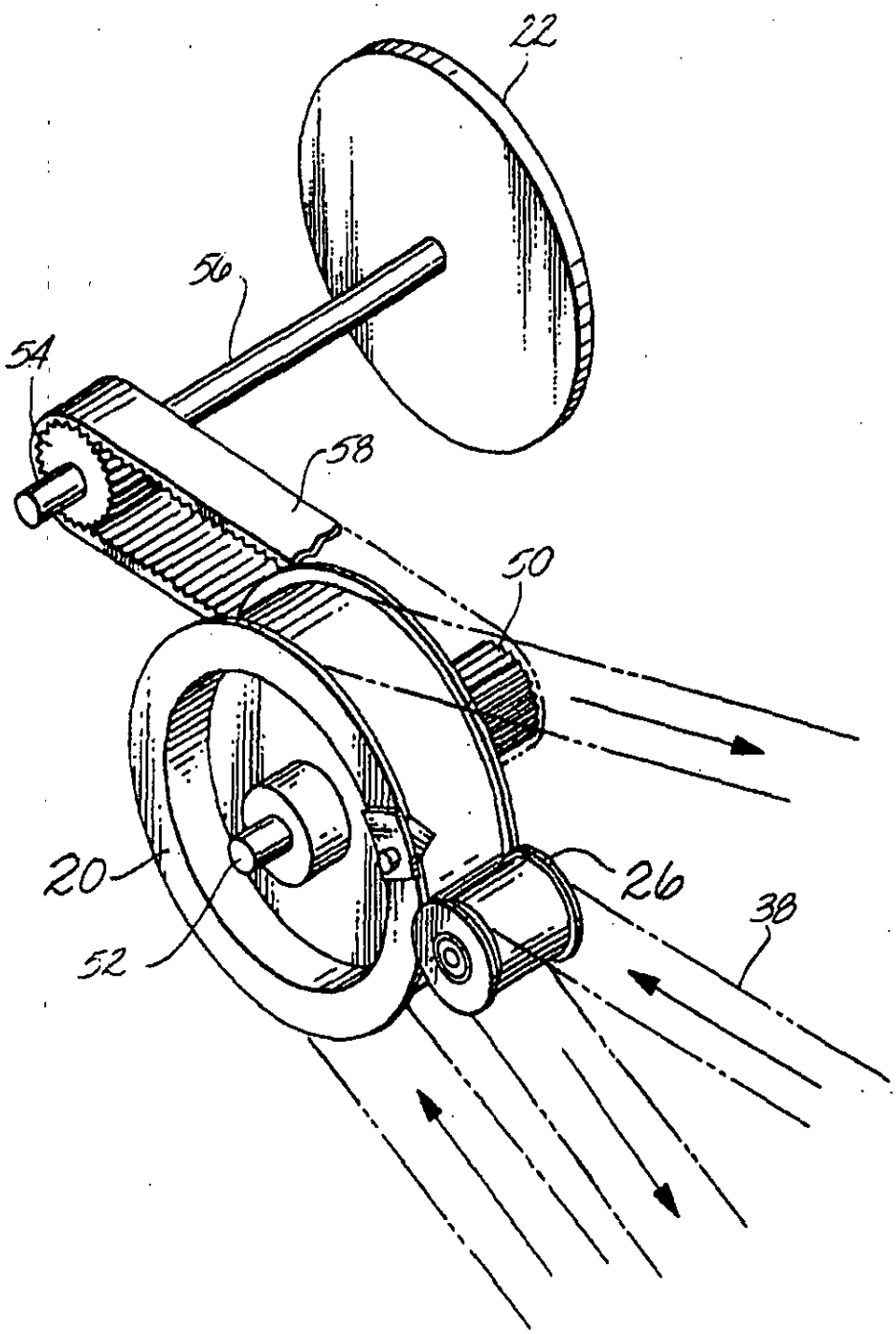


Exhibit: A

Page: 13

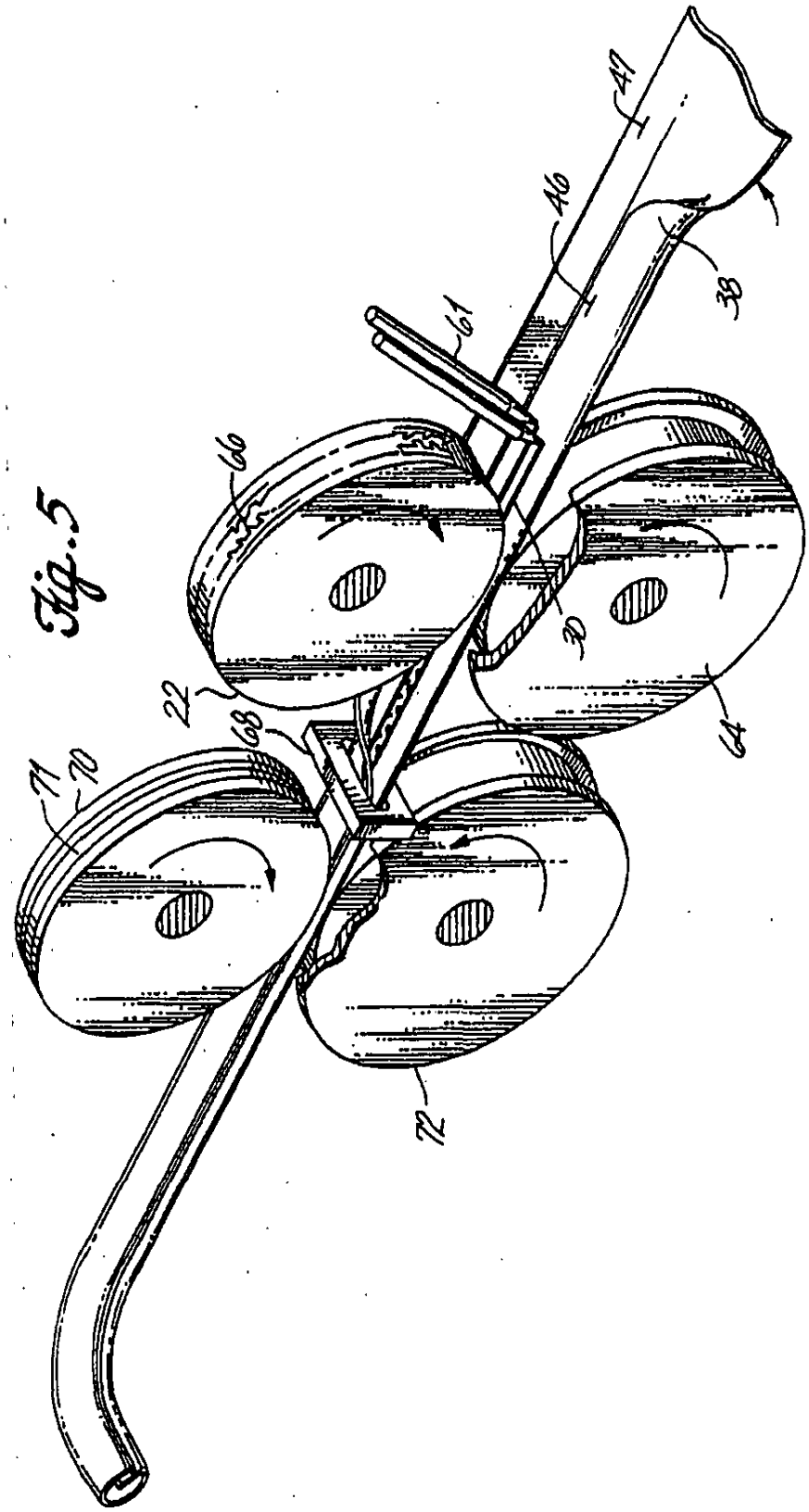


Fig. 5

Exhibit: A

Page: 14

DRIP IRRIGATION HOSE AND METHOD FOR ITS MANUFACTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 08/067,382, filed May 26, 1993, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to drip irrigation and, more particularly, to a drip irrigation hose with an improved outlet construction and a method for its manufacture.

Drip irrigation hose can be classified into two types—those having discrete emitters and those having continuous, integral emitters. An example of a drip irrigation hose having discrete emitters is shown in U.S. Pat. No. 4,850,531. An example of a drip irrigation hose having continuous, integral emitters is shown in U.S. Pat. No. 4,247,051. A drip irrigation hose having continuous integral emitters offers the possibility of lower cost and ease of manufacture and installation.

The design of the inlets to and outlets from the emitters is critical. If the effective outlet area of the emitters is too large, dirt and debris can collect externally in the outlets, thereby causing external clogging. If the effective inlet and outlet areas of the emitters are too small, they become clogged internally and cease to serve their purpose. Further, if the effective outlet areas of the emitters are too small, water squirts out of the hose instead of dripping, and soil erosion results.

U.S. Pat. No. 4,247,051 discloses a drip irrigation hose formed by bending a strip plastic film along its length to form an overlapping longitudinal seam between opposing longitudinal margins of the film. First and second longitudinally extending, laterally spaced, transverse ribs interconnect the opposing margins along their length to seal the overlapping longitudinal seam. The ribs are formed by one or more molten plastic beads extruded onto the film. As a result, a flow regulating passage is defined by the ribs and the opposing margins and a supply passage is defined by the remainder of the film. Water flows from the supply passage to the flow regulating passage through a plurality of longitudinally spaced inlets. Water flows from the flow regulating passage to the exterior of the hose through a plurality of longitudinally spaced outlets longitudinally spaced from the respective inlets to provide a substantial path length from each inlet to a respective outlet. In one embodiment, the outlets each comprise two parallel slits that form between them a flexible flap. The flap serves as an outlet valve, opening and closing as the hose is pressurized and depressurized. However, unless the plastic film is very thick and rigid, the flaps do not close consistently when the hose is depressurized and therefore, the outlets can become clogged by soil driven into the slits.

A problem encountered in the manufacture of continuous emitter type irrigation hose is coordinating the position of the outlets and the track pattern of the ribs. If care is not taken, the track pattern of the ribs may overlap the outlets, and thereby cause the outlets to be on the high pressure side of the flow regulating passages.

SUMMARY OF THE INVENTION

One aspect of the invention is a drip irrigation hose of the continuous emitter type in which the outlets from the respective passage each comprise a single longitudinal slit.

By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized.

Another aspect of the invention is a method for making a drip irrigation hose having longitudinal single slit outlets and/or inlets. A first outlet and/or inlet forming wheel has one or more knife blades on its periphery. A second backing wheel engages the first wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A third rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. A second nip is established with a third wheel in which the desired track pattern is formed. The first and second wheels are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in the following path in the order recited. The film is wrapped around the second wheel to reverse direction and pass into the first nip, thereby forming the outlet slits. The direction of the film is reversed leaving the first nip to transport the film toward the first wheel. The film is wrapped around a portion of the periphery of the first wheel spaced laterally from the knife blade to reverse direction. The direction of the film is reversed to transport the film toward the third wheel. The film is transported under an extruder to deposit a bead of molten plastic on the film before the third wheel. The film is transported into the second nip to form the desired track in the molten plastic. After the film leaves the third wheel, the hose is finished. The described method forms the inlet slits and the track pattern in a coordinated fashion. As a result, the outlets are not restricted or plugged by the ribs.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of specific embodiments of the best mode contemplated of carrying out the invention are illustrated in the drawings, in which:

FIG. 1 is a schematic block diagram of the method for making a drip irrigation hose of the continuous emitter type;

FIG. 2 is a schematic view of a portion of the film path for making a drip irrigation hose in accordance with the invention;

FIG. 3 is a schematic view of a portion of the film path in an alternative embodiment to the film path of FIG. 2;

FIG. 4 is a side partially cutaway view of a length of drip irrigation hose incorporating the principals of the invention; and

FIG. 5 is a schematic diagram of apparatus for completing the manufacture of a drip irrigation hose in accordance with the invention.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

The disclosures of U.S. Pat. Nos. 4,247,051, 4,984,739 and 5,123,984 are incorporated fully herein by reference.

The drip irrigation hose of the invention is made from a continuous strip of flexible, water impervious plastic film, generally ranging in thickness between 4 and 15 mil. As depicted by block 10 in FIG. 1, outlets and/or inlets are formed in the strip of film along one margin. As described

Exhibit: A

Page: 15

in more ... below, each outlet and/or inlet comprises a single lo... ...al slit in the film. Next, as depicted by block 12, two ... plastic beads made of material compatible with the ... deposited by an extruder on the margin of the film ... side of the outlet slits. Next, as depicted by block 14, ... ack pattern of the ribs is formed in the molten beads by ... forming wheel. The track pattern is repeated each time ... rib forming wheel completes a revolution. As depicted by ... ck 16, after the ribs are formed, the margins of the film ... verlapped to position between them the track pattern. ... as depicted by block 18, the overlapping ma... ...ed by the still molten ribs to form the fin... *described steps, except for formation of* the ... ...r inlets, are shown in more detail in the ref... ...patent. Alternatively, either the inlets or the outl... ...e formed as interruptions in one of the ribs.

... ates the path of a continuous strip of film 38 fro... ... drip irrigation hose is made between the for... ... outlets and/or inlets (block 10) and the fo... ...track pattern (block 14). An outlet forming wh... ... rib forming wheel 22 are mounted on a co... ... to synchronize their operation. Wheels 20 ar... ...me diameter. A backing wheel 26 engages ou... ...eel 20 to establish a nip 28 therebetween. A... ... is mounted on the periphery of wheel 20. W... ... circumferential slot 32 into which knife bla... ...ip 28. Direction changing wheels 34 and 36 als... ... of the film path. Wheels 20, 22, 26, 34, and 3... ... to guide film 38 laterally during the manu... fa... ...on.

...around its periphery, impressions 66 (FIG. 5) ... desired track pattern, for example, one of th... ...s is shown in the '051 patent or in the '739 pa... ...on of movement of film 38 is depicted by th... ...G. 2. Film 38 is wrapped around wheel 26 to... ...n and pass into nip 28. As a result, a slit is ... ...38 *each time* blade 30 *passes into nip* 28. A... ...each time wheel 20 completes one revolu... ti... ...ing wheel 26, film 38 is wrapped around w... ...se direction and return toward wheel 20. Fi... ...ed around a portion of the periphery of w... ...laterally from knife blade 30, to reverse d... ...aving wheel 20, film 38 is wrapped around w... ...se direction and move toward wheel 22. W... ...be canted slightly to provide a smooth tr... ...n path between wheels 20 and 22, and the fi... ...slightly between wheels 36 and 22. As sl... ..., between wheels 36 and 22, film 38 passes u... ...which deposit one or more molten plastic be... ...argin of film 38. A backing wheel 64 u... ...2 to form a nip through which film 38 p... molten beads. Since wheels 20 and 22 are n... ...mon shaft, the formation of the outlets and tl... ... coordinated and their relative positioning is... ...ed. After leaving wheel 22, film 38 is fl... ...ther illustrated in FIG. 5 *Specifically, the* e... ...ng margin of film 38 is folded by a guide 6... ...internal overlapping margin of film 38. As a... ...erlapped film 38 passes through the nip of a... ...nd a backing wheel 72. Form wheel 70 has a... ...presses the beads formed by extruders 61 to... ...ht at a specified value that determines the fl... ...ce. In a typical embodiment, the diameter o... ...2 would be about from 3 to 6 inches, the d... ...6 would be about 4 inches, the diameters o... ... 36 would be about 4 inches, and the d... wheels 22 and 36 would be about 24 in...

If the inlets also comprise slits another knife blade is mounted on the periphery of wheel 20 laterally spaced from knife blade 30 and wheel 26 has another circumferential slot laterally spaced from slot 32 into which the other knife blade fits. The inlets as well as the outlets are formed as the respective knife blades pass into nip 28.

FIG. 3 illustrates an alternative film path arrangement that *permits wheels 20 and 22 to have different diameters so that* the outlet spacing can be greater than the track pattern length, which produces a skip in the outlet configuration. Wheel 20 and a toothed wheel 50 are mounted on a shaft 52. Wheel 22 and a toothed wheel 54 are mounted on a shaft 56. A toothed belt 58 couples wheels 50 and 54 to synchronize the rotation of wheels 20 and 22 in a ratio to cause the desired skip in the outlet spacing relative to the track pattern length. In short toothed wheels 50 and 54 and toothed belt 58 replace shaft 24 in the embodiment of FIG. 2. The diameters of wheels 20, 22, 50, and 54 are selected so the angular velocity of wheel 22 is a multiple of the angular velocity of wheel 20, depending upon the desired outlet skip. As a result, the same rib forming wheel 22 can be used to produce a variety of outlet spacings, i.e., skipped outlet configurations.

In FIG. 4, the completed drip irrigation hose is shown. Strip 38 is bent along its length to form an overlapping longitudinal seam between an interior margin and an exterior margin of the strip. Spaced apart, transverse ribs 42 and 43 extend longitudinally through the seam to connect the margins of strip 38, forming a seal and a flow regulating passage 44 therebetween. A water supply passage 45, having a much larger cross-section area then flow regulating passage 44 is defined by the remainder of strip 38. Longitudinally spaced apart slits 46 in the portion of strip 38 between supply passage 45 and flow regulating passage 44 serve as inlets to flow regulating passage 44. Longitudinally spaced apart slits 47, formed in the exterior margin of strip 38, serve as outlets from the hose. Slits 47 are displaced from the respective slits 46 to provide a substantial path length from each inlet to a respective outlet. Preferably, cross ribs 48 are employed to divide the flow regulating passage into segments, *such that slit 46 is at one end of the segment and a* slit 47 is at the other end of a segment. Alternatively, the inlets could be formed by interruptions in rib 42 as illustrated in FIGS. 5 and 6 of the '051 patent and as illustrated in the '739 patent. The shape of ribs 42, 43 and 48 are determined by the track pattern on wheel 22 (FIG. 2). Preferably, chevrons are formed on the adjacent interior surfaces of ribs 42 and 43 to create turbulent flow in the flow regulating passage as illustrated in the '739 patent.

By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. Typically, the line pressure of the water used for crop irrigation ranges from about 4 psig to 14 psig. Slits 47 are *sufficiently long and strip 38 is sufficiently flexible so the* water drips from the outlets when the hose is pressurized, rather than squirting. The effective area of the outlets remains small because the material on both sides of the slits remain in the same plane, rather than buckling. If the slits are too short or the strip is too rigid, the material on either side of the slits does not move sufficiently to make a large hole when the hose is pressurized and water squirts out the hose and erodes the soil. Slits 47 are sufficiently short and strip 38 is sufficiently rigid so the outlets close completely when the hose is depressurized. If the slits are too long or the strip is too flexible, the slits do not close when the hose is depressurized. Typically, the slits are about ¼ inch for a 4 mil film

Exhibit: A

Page: 16

thickness the slits are about ⅛ inch for a 15 mil film thickness, if the slits are much shorter than about ¼ inch for a film thickness or if the film is much thicker than about 15 mil for a slit length of about ¼ inch, the water may not flow to outlets. Similarly, if the slits are much longer than about ½ inch for a 15 mil film thickness or if the film is thinner than about 15 mil for a slit length of about ¼ inch, outlets may not close after the hose is depressurized.

The foregoing embodiment of the invention is only considered preferred and illustrative of the inventive concepts. The scope of the invention is not to be restricted to such embodiments. Various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of this invention.

I claim:

1. A drip irrigation hose comprising:

a flexible strip of plastic film bent along its length with a lapped longitudinal seam between the longitudinal margins of the film;

flexible longitudinally extending transverse ribs in spaced apart relationship interconnecting the overlapping film along their length to seal the overlapping longitudinal seam, thereby forming a flow passage defined by the ribs and a water supply passage defined at least in part by the remainder of the seam;

a plurality of longitudinally spaced inlet ports to the flow passage from the water supply passage;

a plurality of longitudinally spaced outlet ports from the flow passage displaced from the respective inlet ports to provide a substantial path length from the inlet port to a respective outlet port,

each of said outlet ports comprising a single longitudinal slit, the slit being sufficiently long and the strip being sufficiently flexible so the water drips from the outlet ports when the hose is pressurized, the slit being sufficiently short and the strip being sufficiently resilient so the slit closes completely when the hose is depressurized.

2. A drip irrigation hose as claim 1, in which the inlet ports are also slits.

3. A method of making drip irrigation hose comprising:

providing a port forming wheel having a knife blade on its periphery;

providing a backing wheel engaging the outlet forming wheel to establish a first nip therebetween, the backing wheel having on its periphery a circumferential slot into which the knife blade fits at the first nip;

providing a rib forming wheel having around its periphery impressions that define a desired track pattern;

establishing with the third wheel a second nip in which the desired track pattern is formed;

a common shaft on which the first and third wheels are mounted to operate in synchronism;

first guiding means for wrapping a continuous strip of plastic film around the second wheel to reverse direction and pass into the first nip;

second guiding means for reversing direction of the film leaving the first nip to transport the film toward the first wheel;

third guiding means for wrapping the film around a portion of periphery of the first wheel spaced laterally from the knife blade to reverse direction;

fourth guiding means for reversing direction of the film to transport the film toward the third wheel;

means for depositing a bead of molten plastic on the film between the fourth guiding means and the third wheel;

fifth guiding means for transporting the film into the second nip to form the desired track in the molten plastic; and

means for finishing the hose after the strip of film leaves the third wheel.

4. A method for making drip irrigation hose with a first port forming wheel having a knife blade on its periphery, a second backing wheel engaging the port forming wheel to establish a first nip therebetween, the backing wheel having on its periphery a circumferential slot into which the knife blade fits at the first nip, and a third rib forming wheel having around its periphery impressions that define a desired track pattern, the method comprising the steps of:

establishing with the third wheel a nip in which the desired track pattern is formed;

mounting the first and third wheels on a common shaft to operate in synchronism;

directing a continuous strip of plastic film in the following path in the order recited:

wrapping the film around the second wheel to reverse direction and pass into the first nip, thereby forming outlet slits;

reversing direction of the film leaving the first nip to transport the film toward the first wheel;

wrapping the film around a portion of periphery of the first wheel spaced laterally from the knife blade to reverse direction;

reversing direction of the film to transport the film toward the third wheel;

transporting the film under an extruder to deposit a bead of molten plastic on the film before the third wheel; and

transporting the film into the second nip to form the desired track in the molten plastic; and

finishing the hose after the strip of film leaves the third wheel.

* * * * *

Exhibit: A

Page: 17

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PAT : 5,522,551

DAT : June 4, 1996

IN : Michael DeFrank; David Marchetti; David L. Teegardin

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On title page, [63] Related U.S. Application Data, change "May 26, 1993" to -- May 25, 1993 --.

Column 1, line 8, change "May 26, 1993" to -- May 25, 1993 --.

Column 7, line 3, after "wheel 26" insert -- and --.

Column 7, line 48, after "wheel;" delete "and".

Column 8, after claim 4, insert claims 5 and 6 as follows:

-- 5. The hose of claim 1, in which the slit in the strip that comprises each outlet port is formed by a knife blade. --

-- 6. The hose of claim 2, in which the slits that comprise the inlet ports and the outlet ports are both formed by a knife blade. --

Signed and Sealed this

Fifteenth Day of April, 1997

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

Exhibit: A

Page: 18

Exhibit B

US005634595A

United States Patent [19]

DeFrank et al.

[11] Patent Number: 5,634,595

[45] Date of Patent: *Jun. 3, 1997

[54] DRIP IRRIGATION HOSE AND METHOD FOR ITS MANUFACTURE

[75] Inventors: Michael DeFrank, Temecula; David Marchetti; David L. Teegardin, both of San Diego, all of Calif.

[73] Assignee: T-Systems International, Inc., San Diego, Calif.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,522,551.

[21] Appl. No.: 650,469

[22] Filed: May 20, 1996

Related U.S. Application Data

[63] Continuation of Ser. No. 279,813, Jul. 19, 1994, Pat. No. 5,522,551.

[51] Int. Cl.[6] B05B 15/00

[52] U.S. Cl. 239/542; 239/533.13; 156/252

[58] Field of Search ..... 239/107, 533.1, 239/533.13, 533.15, 542, 562, 566, 568, 602, DIG. 12; 156/120-3, 252, 465, 466, 513

[56] References Cited

U.S. PATENT DOCUMENTS

4,0[illegible]9	10/1977	Gilead	239/542
4,1[illegible]9	2/1979	Inoue et al.	239/547
4,17[illegible]2	11/1979	Gilead	405/43
4,1[illegible]4	4/1980	Gilead	239/542
4,2[illegible]51	1/1981	Allport	239/542
4,5[illegible]60	10/1985	Delmer et al.	239/542
4,77[illegible]01	10/1988	Tsumi	239/276
4,98[illegible]39	1/1991	Allport	239/193
5,123,984	6/1992	Allport et al.	156/203
5,522,551	6/1996	DeFrank et al.	239/542

FOREIGN PATENT DOCUMENTS

2508865	9/1976	European Pat. Off. .
46345	12/1974	Israel .
52184	5/1977	Israel .
50051	11/1979	Israel .

OTHER PUBLICATIONS

Hardie Irrigation product information sheet (no date given).
Sample of Hardie Irrigation product with slit open to expose inside (Hardie Tape) (no date).

Primary Examiner—Andres Kashnikow
Assistant Examiner—Lisa Ann Douglas
Attorney, Agent, or Firm—Christie, Parker & Hale, LLP

[57] ABSTRACT

A drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized. An outlet forming wheel has a knife blade on its periphery. A backing wheel engages the outlet forming wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. The outlet forming wheel and the rib forming wheel are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in a path that reverses direction four times to accommodate these wheels.

11 Claims, 3 Drawing Sheets

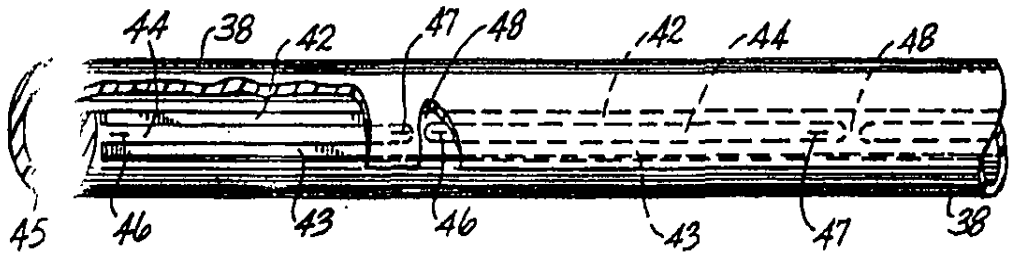


Exhibit: B

Page: 19

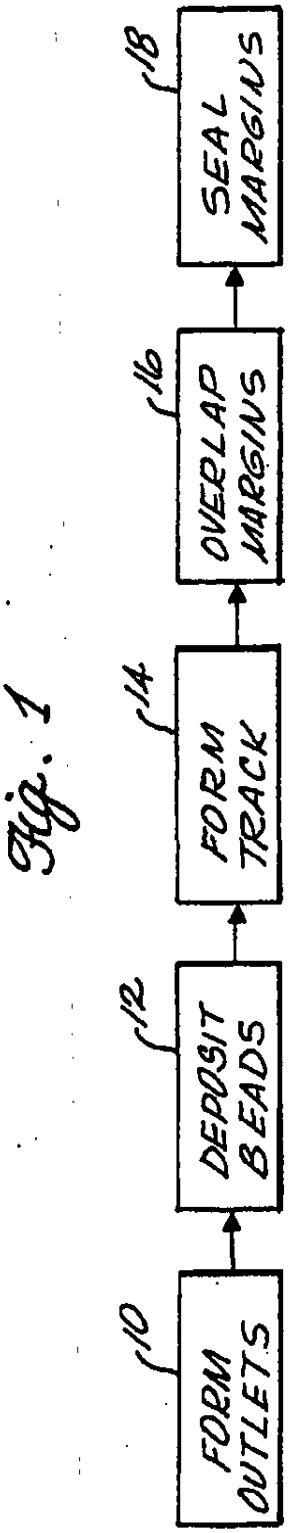


Fig. 1

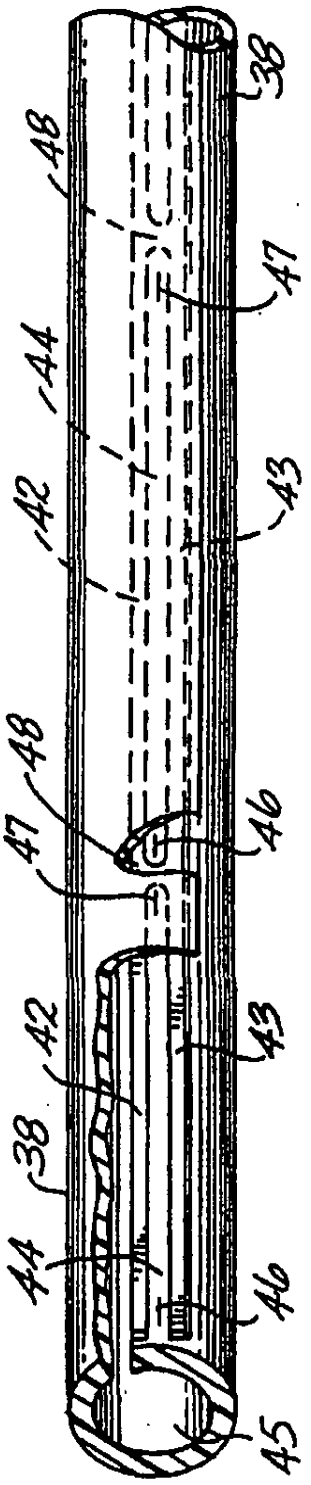


Fig. 4

Exhibit: B
Page: 20

Fig. 2

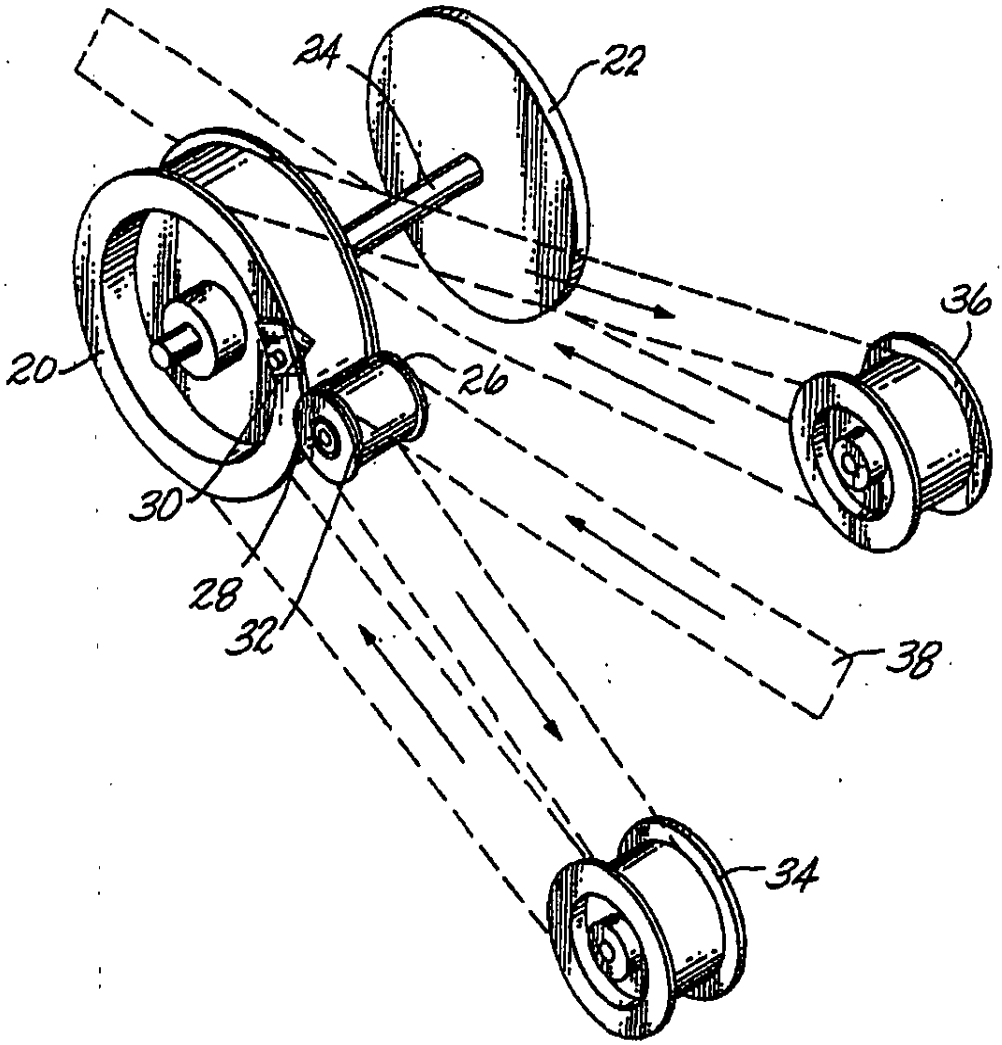


Exhibit: B
Page: 21

Fig. 3

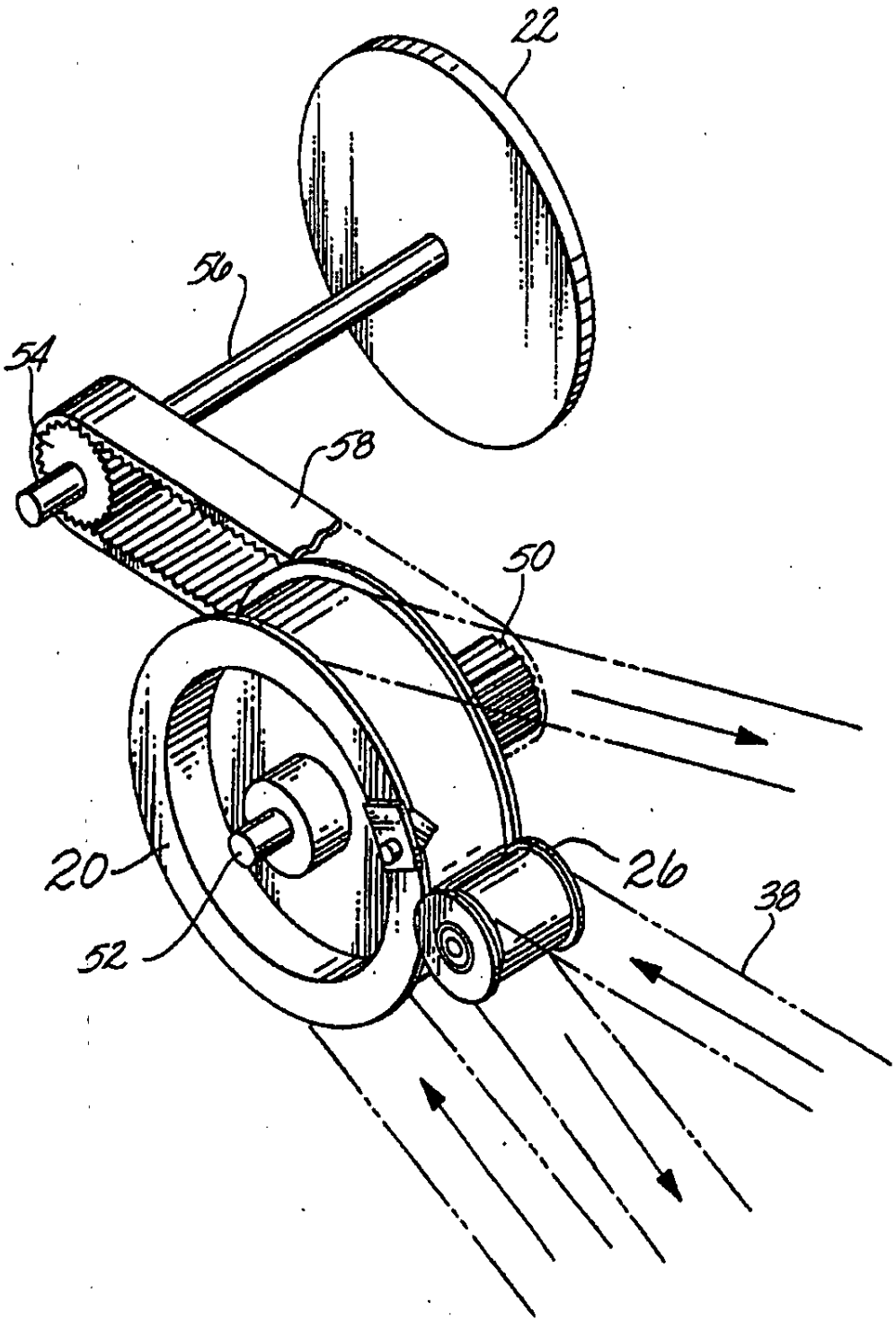


Exhibit: B
Page: 12

DRIP IRRIGATION HOSE AND METHOD FOR ITS MANUFACTURE

CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation of application Ser. No. 08/279,813 filed Jul. 19, 1994, now U.S. Pat. No. 5,522,551.

BACKGROUND OF THE INVENTION

This invention relates to drip irrigation and, more particularly, to a drip irrigation hose with an improved outlet construction and a method for its manufacture.

Drip irrigation hose can be classified into two types—hose having discrete emitters and hose having continuous, integral emitters. An example of a drip irrigation hose having discrete emitters is shown in U.S. Pat. No. 4,850,531. An example of a drip irrigation hose continuous, integral emitters is shown in U.S. Pat. No. 4,247,051. Drip irrigation hose having continuous integral emitters offers the possibility of lower cost and ease of manufacture and installation.

The design of the inlets to and outlets from the emitters is critical. If the effective outlet area of the emitters is too large, dirt and debris can collect externally in the outlets, thereby causing external clogging. If the effective inlet and outlet areas of the emitters are too small, they become clogged internally and cease to serve their purpose. Further, if the effective outlet areas of the emitters are too small, water squirts out of the hose instead of dripping, and soil erosion results.

U.S. Pat. No. 4,247,051 discloses a drip irrigation hose formed by bending a strip plastic film along its length to form an overlapping longitudinal seam between opposing longitudinal margins of the film. First and second longitudinally extending, laterally spaced, transverse ribs interconnect the opposing margins along their length to seal the overlapping longitudinal seam. The ribs are formed by one or more molten plastic beads extruded onto the film. As a result, a flow regulating passage is defined by the ribs and the opposing margins and a supply passage is defined by the remainder of the film. Water flows from the supply passage to the flow regulating passage through a plurality of longitudinally spaced inlets. Water flows from the flow regulating passage to the exterior of the hose through a plurality of longitudinally spaced outlets longitudinally spaced from the respective inlets to provide a substantial path length from each inlet to a respective outlet. In one embodiment, the outlets each comprise two parallel knife blade formed slits that create between them a flexible flap. The flap serves as an outlet valve, opening and closing as the hose is pressurized and depressurized. However, unless the plastic film is very thick and rigid, the flaps do not close consistently when the hose is depressurized and therefore, the outlets can become clogged by soil drawn into the slits.

In other types of drip irrigation hose, elongated slot-like outlets are sometimes formed by a laser than vaporizes part of the plastic film. When the water is turned off, the outlets may not completely close because of the removed material.

A problem encountered in the manufacture of continuous emitter drip irrigation hose is coordinating the position of the outlets and the track pattern of the ribs. If care is not taken, the track pattern of the ribs may overlap the outlets, and thereby cause the outlets to be on the high pressure side of the flow regulating passages.

SUMMARY OF THE INVENTION

One aspect of the invention is a drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized.

Another aspect of the invention is a method for making a drip irrigation hose having longitudinal single slit outlets and/or inlets. A first outlet and/or inlet forming wheel has one or more knife blades on its periphery. A second backing wheel engages the first wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A third rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. A second nip is established with a third wheel in which the desired track pattern is formed. The first and second wheels are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in the following path in the order recited. The film is wrapped around the second wheel to reverse direction and pass into the first nip, thereby forming the outlet slits. The direction of the film is reversed leaving the first nip to transport the film toward the first wheel. The film is wrapped around a portion of the periphery of the first wheel spaced laterally from the knife blade to reverse direction. The direction of the film is reversed to transport the film toward the third wheel. The film is transported under an extruder to deposit a bead of molten plastic on the film before the third wheel. The film is transported into the second nip to form the desired track in the molten plastic. After the film leaves the third wheel, the hose is finished. The described method forms the outlet slits and the track pattern in a coordinated fashion. As a result, the outlets are not restricted or plugged by the ribs.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of specific embodiments of the best mode contemplated of carrying out the invention are illustrated in the drawings, in which:

FIG. 1 is a schematic block diagram of the method for making a drip irrigation hose of the continuous emitter type;

FIG. 2 is a schematic view of a portion of the film path for making a drip irrigation hose in accordance with the invention;

FIG. 3 is a schematic view of a portion of the film path in an alternative embodiment to the film path of FIG. 2; and

FIG. 4 is a side partially cutaway view of a length of drip irrigation hose incorporating the principals of the invention.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

The disclosures of U.S. Pat. Nos. 4,247,051, 4,984,739 and 5,123,984 are incorporated fully herein by reference.

The drip irrigation hose of the invention is made from a continuous strip of flexible, water impervious plastic film, generally ranging in thickness between 4 and 15 mil. As depicted by block 10 in FIG. 1, outlets and/or inlets are formed in the strip of film along one margin. As described in more detail below, each outlet and/or inlet comprises a single longitudinal knife blade formed slit in the film. Next, as depicted by block 12, two molten plastic beads made of material compatible with the film are deposited by an

extruder on the margin of the film on either side of the outlet slits. Next, as depicted by block 14, the track pattern of the ribs is formed in the molten beads by a rib forming wheel. The track pattern is repeated each time the rib forming wheel completes a revolution. As depicted by block 16, after the ribs are formed, the margins of the film are overlapped to position between them the track pattern. Finally, as depicted by block 18, the overlapping margins are sealed by the still molten ribs to form the finished hose. The described steps, except for formation of the outlets and/or inlets, are shown in more detail in the referenced '984 patent. Alternatively, either the inlets or the outlets could be formed as interruptions in one of the ribs.

FIG. 2 illustrates the path of a continuous strip of film 38 from which the drip irrigation hose is made between the formation of the outlets and/or inlets (block 10) and the formation of the track pattern (block 14). An outlet forming wheel 20 and a rib forming wheel 22 are mounted on a common shaft 24 to synchronize their operation. Wheels 20 and 22 have the same diameter. A backing wheel 26 engages outlet forming wheel 20 to establish a nip 28 therebetween. A knife blade 30 is mounted on the periphery of wheel 20. Wheel 26 has a circumferential slot 32 into which knife blade 30 fits at nip 28. Direction changing wheels 34 and 36 also define part of the film path. Wheels 20, 22, 26, 34, and 36 have flanges to guide film 38 laterally during the manufacturing operation.

Wheel 22 has, around its periphery, impressions (not shown) that define the desired track pattern, for example, one of the track patterns is shown in the '051 patent or in the '739 patent. The direction of movement of film 38 is depicted by the arrows in FIG. 2. Film 38 is wrapped around wheel 26 to reverse direction and pass into nip 28. As a result, a slit is formed in film 38 each time blade 30 passes into nip 28. A slit is formed each time wheel 20 completes one revolution. After leaving wheel 26, film 38 is wrapped around wheel 34 to reverse direction and return toward wheel 20. Film 38 is wrapped around a portion of the periphery of wheel 20, spaced laterally from knife blade 30, to reverse direction. After leaving wheel 20, film 38 is wrapped around wheel 36 to reverse direction and move toward wheel 22. Wheel 36 could be canted slightly to provide a smooth transition in the film path between wheels 20 and 22, and the film could twist slightly between wheels 36 and 22. Between wheels 36 and 22, film 38 passes under an extruder 40 which deposits one or more molten plastic beads on one margin of film 38. A backing wheel (not shown) underlies wheel 22 to form a nip through which film 38 passes to form the molten beads. Since wheels 20 and 22 are mounted on a common shaft, the formation of the outlets and the track pattern is coordinated and their relative positioning is closely controlled. After leaving wheel 22, film 38 is finished in the manner illustrated in FIG. 5 of the '984 patent. In a typical embodiment, the diameters of wheels 20 and 22 would be about from 3 to 6 inches, the diameter of wheel 26 would be about 4 inches, the diameters of wheels 34 and 36 would be about 4 inches, and the distance between wheels 22 and 36 would be about 24 inches.

If the inlets also comprise slits another knife blade is mounted on the periphery of wheel 20 laterally spaced from knife blade 30 and wheel 26 has another circumferential slot laterally spaced from slot 32 into which the other knife blade fits. The inlets as well as the outlets are formed as the respective knife blades pass into nip 28.

FIG. 3 illustrates an alternative film path arrangement that permits wheels 20 and 22 to have different diameters so that the outlet spacing can be greater than the track pattern length, which produces a skip in the outlet configuration. Wheel 20 and a toothed wheel 50 are mounted on a shaft 52. Wheel 22 and a toothed wheel 54 are mounted on a shaft 56. A toothed belt 58 couples wheels 50 and 54 to synchronize the rotation of wheels 20 and 22 in a ratio to cause the desired skip in the outlet spacing relative to the track pattern length. In short toothed wheels 50 and 54 and toothed belt 58 replace shaft 24 in the embodiment of FIG. 2. The diameters of wheels 20, 22, 50, and 54 are selected so the angular velocity of wheel 22 is a multiple of the angular velocity of wheel 20, depending upon the desired outlet skip. As a result, the same rib forming wheel 22 can be used to produce a variety of outlet spacings, i.e., skipped outlet configurations.

In FIG. 4, the completed drip irrigation hose is shown. Strip 38 is bent along its length to form an overlapping longitudinal seam between an interior margin and an exterior margin of the strip. Spaced apart, transverse ribs 42 and 43 extend longitudinally through the seam to connect the margins of strip 38, forming a seal and a flow regulating passage 44 therebetween. A water supply passage 45, having a much larger cross-section area than flow regulating passage 44 is defined by the remainder of strip 38. Longitudinally spaced apart slits 46 in the portion of strip 38 between supply passage 45 and flow regulating passage 44 serve as inlets to flow regulating passage 44. Longitudinally spaced apart slits 47, formed in the exterior margin of strip 38, serve as outlets from the hose. Slits 47 are displaced from the respective slits 46 to provide a substantial path length from each inlet to a respective outlet. Preferably, cross ribs 48 are employed to divide the flow regulating passage into segments, such that slit 46 is at one end of the segment and a slit 47 is at the other end of a segment. Alternatively, the inlets could be formed by interruptions in rib 42 as illustrated in FIGS. 5 and 6 of the '051 patent and as illustrated in the '739 patent. The shape of ribs 42, 43 and 48 are determined by the track pattern on wheel 22 (FIG. 2). Preferably, chevrons are formed on the adjacent interior surfaces of ribs 42 and 43 to create turbulent flow in the flow regulating passage as illustrated in the '739 patent.

By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. Typically, the line pressure of the water used for crop irrigation ranges from about 4 psig to 14 psig. Slits 47 are sufficiently long and strip 38 is sufficiently flexible so the water drips from the outlets when the hose is pressurized, rather than squirting. The effective area of the outlets remains small because the material on both sides of the slits remain in the same plane, rather than buckling. If the slits are too short or the strip is too rigid, the material on either side of the slits does not move sufficiently to make a large hole when the hose is pressurized and water squirts out the hose and erodes the soil. Slits 47 are sufficient short and strip 38 is sufficiently rigid so the outlets close completely when the hose is depressurized. If the slits are too long or the strip is too flexible, the slits do not close when the hose is depressurized. Typically, the slits are about ¼ inch for a 4 mil film thickness and the slits are about ⅓ inch for a 15 mil film thickness. Thus, if the slits are much shorter than about ¼ inch for a 4 mil film thickness or if the film is much thicker than about 4 mil for a slit length of about ¼ inch, the water may squirt from the outlets. Similarly, if the slits are much longer than about ⅓ inch for a 15 mil film thickness or if the film is much thinner than about 15 mil for a slit length of about ⅓ inch, the outlets may not close after the hose is depressurized.

Exhibit: B

Page: 24

The described embodiment of the invention is only considered to be preferred and illustrative of the inventive concept; the scope of the invention is not to be restricted to such embodiments. Various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of this invention.

What is claimed is:

1. A drip irrigation hose comprising:

an elongated flexible strip of plastic film bent along its length to form a lapped longitudinal seam between opposing longitudinal margins of the film;

means for interconnecting the opposing margins along their length to seal the overlapping longitudinal seam, thereby forming a flow regulating passage defined by the seam and a water supply passage defined at least in part by the remainder of the strip;

a plurality of longitudinally spaced inlet ports to the flow regulating passage from the water supply passage;

a plurality of longitudinally spaced outlet ports from the flow regulating passage displaced from the respective inlet ports to provide a substantial path length from each inlet port to a respective outlet port,

wherein each outlet port comprises a single longitudinal slit in the strip, the slit being sufficiently long and the strip being sufficiently flexible so the water drips from the port when the hose is pressurized, the slit being sufficiently short and the strip being sufficiently rigid so the slit closes completely when the hose is depressurized.

2. The hose of claim 1, in which each slit is knife blade formed.

3. A drip irrigation hose comprising:

an elongated flexible strip of plastic film bent along its length to form a lapped longitudinal seam between opposing longitudinal margins of the film;

means for interconnecting the opposing margins along their length to seal the overlapping longitudinal seam and thereby form a large water supply passage;

means for forming a flow regulating passage that is much smaller than the water supply passage;

a plurality of longitudinally spaced inlet ports to the flow regulating passage from the water supply passage;

a plurality of longitudinally spaced outlet ports from the flow regulating passage displaced from the respective inlet ports to provide a substantial path length from each inlet port to a respective outlet port,

wherein each outlet port comprises a single longitudinal knife blade formed slit in the strip.

4. The hose of claim 3, in which the slits are sufficiently long and the strip is sufficient flexible so the water drips from the port when the hose is pressurized, and the slits are sufficiently short and the strip is sufficiently rigid so the slits close completely when the hose is depressurized.

5. A drip irrigation hose comprising:

an elongated flexible strip of plastic film bent along its length to form a lapped longitudinal seam between opposing longitudinal margins of the film;

means for interconnecting the opposing margins along their length to seal the overlapping longitudinal seam, thereby forming a flow regulating passage defined by the seam and a water supply passage defined at least in part by the remainder of the strip;

a plurality of longitudinally spaced inlet ports to the flow regulating passage from the water supply passage;

a plurality of longitudinally spaced outlet ports from the flow regulating passage displaced from the respective inlet ports to provide a substantial path length from each inlet port to a respective outlet port,

wherein each port of one type comprises a single longitudinal knife blade formed slit in the strip.

6. Apparatus for making drip irrigation hose comprising:

an outlet port forming wheel having a knife blade on its periphery;

means for wrapping a continuous moving strip of plastic film around the wheel to form slit outlets repeatedly in one margin of the strip with the knife blade;

means for forming a desired track pattern repeatedly on one margin of the film in predetermined relationship with the knife blade formed outlets;

means for overlapping the margins of the film to form a water supply passage;

means for sealing the overlapping margins to form therebetween a flow regulating passage through the track patterns to the outlets; and

means for repeatedly forming inlets from the water supply passage to the flow regulating passage so a track pattern lies between each inlet and outlet.

7. The apparatus of claim 6, in which the pattern forming means comprises a track pattern forming wheel, means for wrapping the strip of plastic film around the track pattern forming wheel to form the track patterns, and means for coupling the track pattern forming wheel to the outlet port forming wheel to operate in synchronism therewith.

8. The apparatus of claim 7, in which the coupling means comprises a shaft connected between the wheels.

9. A method for making drip irrigation hose comprising the steps of:

repeatedly forming slit outlets in one margin of a continuous moving strip of plastic film with a knife blade;

repeatedly forming a desired track pattern on one margin of the film in predetermined relationship with the outlets;

overlapping the margins of the film to form a water supply passage;

sealing the overlapping margins to form therebetween a flow regulating passage through the track patterns to the outlets; and

repeatedly forming inlets from the water supply passage to the flow regulating passage so a track pattern lies between each inlet and outlet.

10. The method of claim 9, in which the step of forming slit outlets comprises wrapping the strip of plastic film around a wheel having a knife blade on its periphery to form a slit outlet each time the wheel rotates.

11. The method of claim 10, in which the step of forming a desired track pattern comprises wrapping the strip of plastic film around a track pattern forming wheel to form a track pattern each time the track pattern forming wheel rotates and coupling the track pattern forming wheel to the outlet port forming wheel to operate in synchronism therewith.

* * * * *

Exhibit: B

Page: 25

Exhibit C

US005865377A

United States Patent [19]

DeFrank et al.

[11] Patent Number: 5,865,377

[45] Date of Patent: *Feb. 2, 1999

[54] **DRIP IRRIGATION HOSE AND METHOD FOR ITS MANUFACTURE**

[75] Inventors: **Michael DeFrank**, Temecula, Calif.; **David Marchetti**, The Woodlands, Tex.; **David L. Teegardin**, San Diego, Calif.

[73] Assignee: **T-Systems International, Inc.**, San Diego, Calif.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. Nos. 5,522,551 and 5,634,595.

[21] Appl. No.: **850,407**

[22] Filed: **May 2, 1997**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 650,469, May 20, 1996, Pat. No. 5,634,595, which is a continuation of Ser. No. 279,813, Jul. 19, 1994, Pat. No. 5,522,551.

[51] **Int. Cl.**[6] **B05B 15/00**

[52] **U.S. Cl.** **239/542**; 239/533.13

[58] **Field of Search** ..... 239/107, 533.1, 239/533.15, 542, 562, 566, 568, 602, DIG. 12, 533.13

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,899,135	8/1975	O'Brian	239/534
4,053,109	10/1977	Gilead	239/542
4,139,159	2/1979	Inoue et al.	239/547
4,175,882	11/1979	Gilead	405/43
4,195,784	4/1980	Gilead	239/542
4,247,051	1/1981	Allport	239/542
4,548,360	10/1985	Delmer et al.	239/542
4,779,800	10/1988	Tuomi	239/276
4,984,739	1/1991	Allport	239/193
5,123,984	6/1992	Allport et al.	156/203
5,522,551	6/1996	DeFrank et al.	239/542
5,634,595	6/1997	Defrank et al.	239/542

FOREIGN PATENT DOCUMENTS

2508865	9/1976	European Pat. Off. .
46345	12/1974	Israel .
52184	5/1977	Israel .
50051	11/1979	Israel .

OTHER PUBLICATIONS

Hardie Irrigation product information sheet (no date).
Sample of Hardie Irrigation product with slit open to expose inside (Hardie Tape).

Primary Examiner—Andres Kashnikow
Assistant Examiner—Lisa Ann Douglas
Attorney, Agent, or Firm—Christie, Parker & Hale, LLP

[57] **ABSTRACT**

A drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized. An outlet forming wheel has a knife blade on its periphery. A backing wheel engages the outlet forming wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. The outlet forming wheel and the rib forming wheel are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in a path that reverses direction four times to accommodate these wheels.

6 Claims, 3 Drawing Sheets

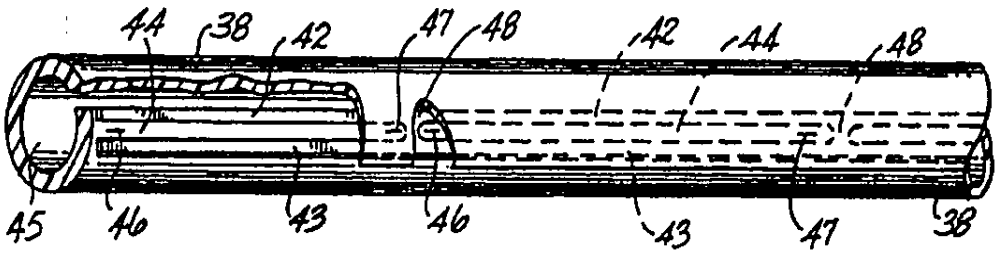


Exhibit: C

Page: 26

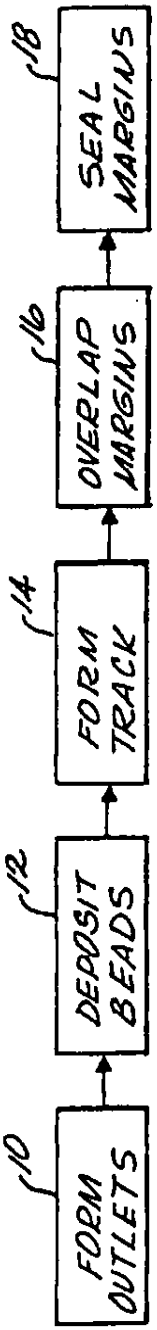


Fig. 1

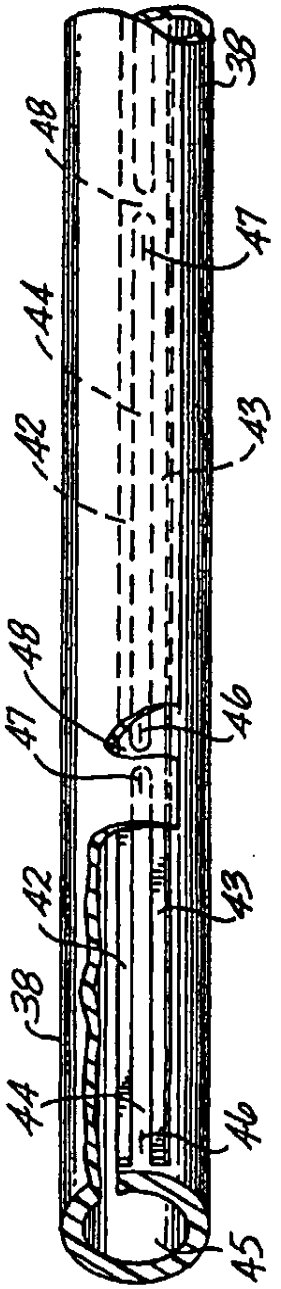


Fig. 4

Exhibit: C
Page: 27

Fig. 2

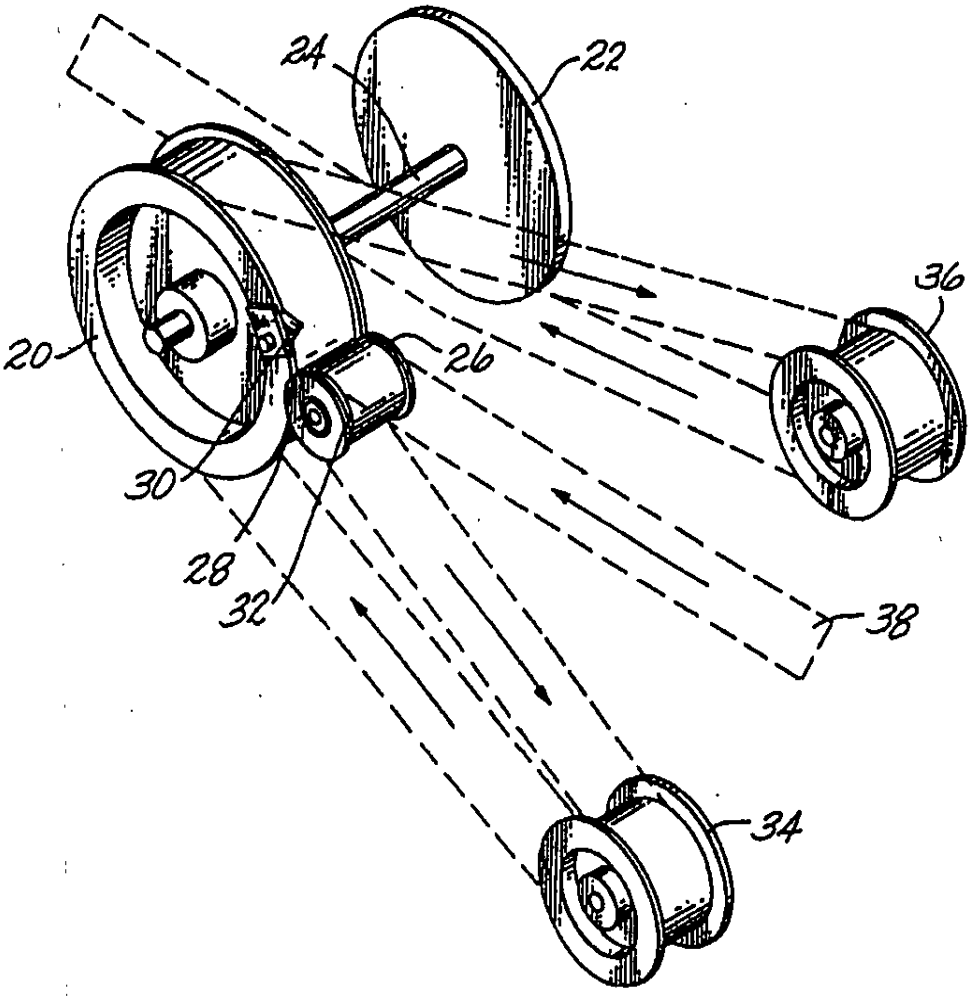


Exhibit: C

Page: 28

Fig. 3

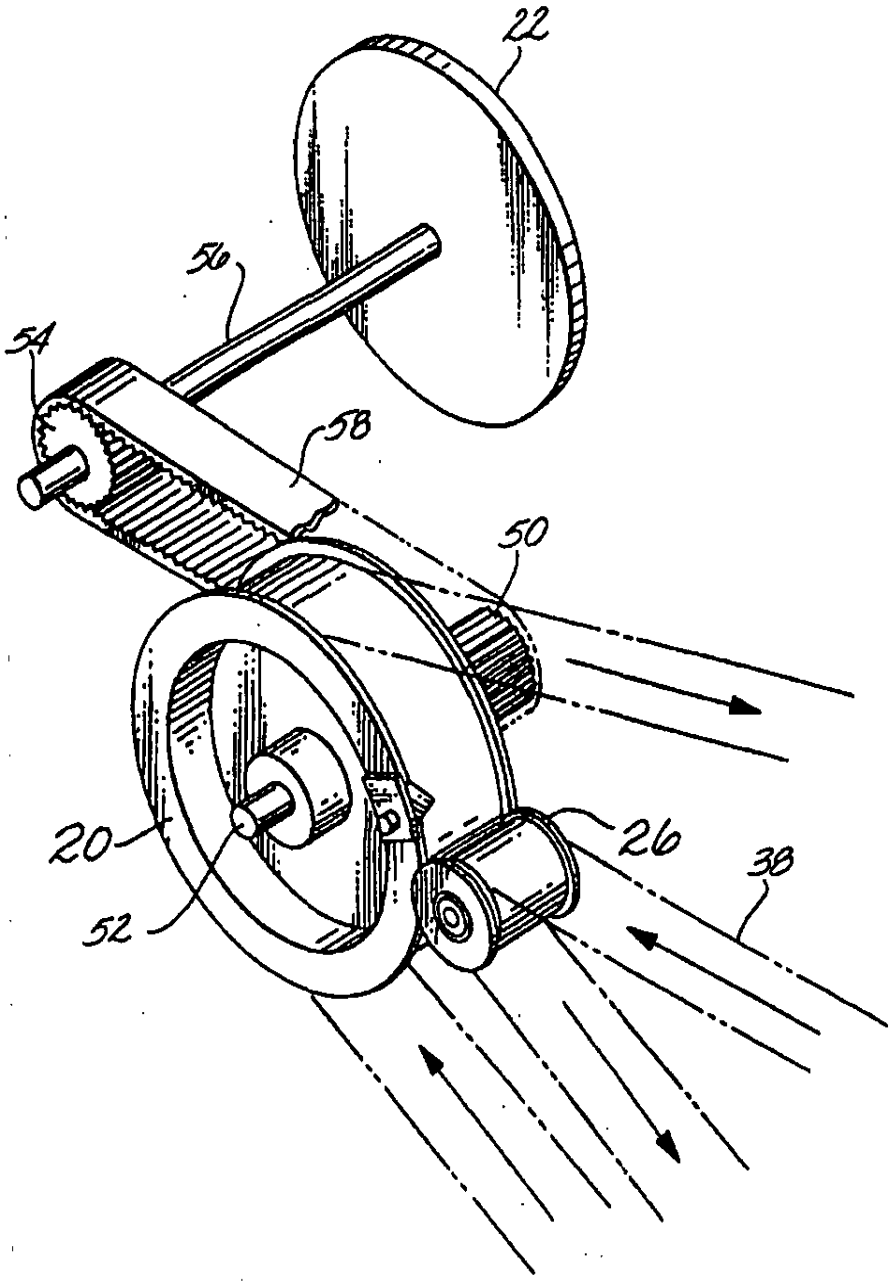


Exhibit: C
Page: 29

DRIP IRRIGATION HOSE AND METHOD FOR ITS MANUFACTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of Application No. 08/650,469 filed May 20, 1996, which issued as U.S. Pat. No. 5,634,595 on Jun. 3, 1997 which is a continuation of Application No. 08/279,813 filed Jul. 19, 1994, which issued as U.S. Pat. No. 5,522,551 on Jun. 4, 1996.

BACKGROUND OF THE INVENTION

This invention relates to drip irrigation and, more particularly, to a drip irrigation hose with an improved outlet construction and a method for its manufacture.

Drip irrigation hose can be classified into two types—hose having discrete emitters and hose having continuous, integral emitters. An example of a drip irrigation hose having discrete emitters is shown in U.S. Pat. No. 4,850,531. An example of a drip irrigation hose continuous, integral emitters is shown in U.S. Pat. No. 4,247,051. Drip irrigation hose having continuous integral emitters offers the possibility of lower cost and ease of manufacture and installation.

The design of the inlets to and outlets from the emitters is critical. If the effective outlet area of the emitters is too large, dirt and debris can collect externally in the outlets, thereby causing external clogging. If the effective inlet and outlet areas of the emitters are too small, they become clogged internally and cease to serve their purpose. Further, if the effective outlet areas of the emitters are too small, water squirts out of the hose instead of dripping, and soil erosion results.

U.S. Pat. No. 4,247,051 discloses a drip irrigation hose formed by bending a strip plastic film along its length to form an overlapping longitudinal seam between opposing longitudinal margins of the film. First and second longitudinally extending, laterally spaced, transverse ribs interconnect the opposing margins along their length to seal the overlapping longitudinal seam. The ribs are formed by one or more molten plastic beads extruded onto the film. As a result, a flow regulating passage is defined by the ribs and the opposing margins and a supply passage is defined by the remainder of the film. Water flows from the supply passage to the flow regulating passage through a plurality of longitudinally spaced inlets. Water flows from the flow regulating passage to the exterior of the hose through a plurality of longitudinally spaced outlets longitudinally spaced from the respective inlets to provide a substantial path length from each inlet to a respective outlet. In one embodiment, the outlets each comprise two parallel slits that form between them a flexible flap. The flap serves as an outlet valve, opening and closing as the hose is pressurized and depressurized. However, unless the plastic film is very thick and rigid, the flaps do not close consistently when the hose is depressurized and therefore, the outlets can become clogged by soil drawn into the slits.

A problem encountered in the manufacture of continuous emitter drip irrigation hose is coordinating the position of the outlets and the track pattern of the ribs. If care is not taken, the track pattern of the ribs may overlap the outlets, and thereby cause the outlets to be on the high pressure side of the flow regulating passages.

SUMMARY OF THE INVENTION

One aspect of the invention is a drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized.

Another aspect of the invention is a method for making a drip irrigation hose having longitudinal single slit outlets and/or inlets. A first outlet and/or inlet forming wheel has one or more knife blades on its periphery. A second backing wheel engages the first wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A third rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. A second nip is established with a third wheel in which the desired track pattern is formed. The first and second wheels are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in the following path in the order recited. The film is wrapped around the second wheel to reverse direction and pass into the first nip, thereby forming the outlet slits. The direction of the film is reversed leaving the first nip to transport the film toward the first wheel. The film is wrapped around a portion of the periphery of the first wheel spaced laterally from the knife blade to reverse direction. The direction of the film is reversed to transport the film toward the third wheel. The film is transported under an extruder to deposit a bead of molten plastic on the film before the third wheel. The film is transported into the second nip to form the desired track in the molten plastic. After the film leaves the third wheel, the hose is finished. The described method forms the outlet slits and the track pattern in a coordinated fashion. As a result, the outlets are not restricted or plugged by the ribs.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of specific embodiments of the best mode contemplated of carrying out the invention are illustrated in the drawings, in which:

FIG. 1 is a schematic block diagram of the method for making a drip irrigation hose of the continuous emitter type;

FIG. 2 is a schematic view of a portion of the film path for making a drip irrigation hose in accordance with the invention;

FIG. 3 is a schematic view of a portion of the film path in an alternative embodiment to the film path of FIG. 2; and

FIG. 4 is a side partially cutaway view of a length of drip irrigation hose incorporating the principals of the invention.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

The disclosures of U.S. Pat. Nos. 4,247,051, 4,984,739 and 5,123,984 are incorporated fully herein by reference.

The drip irrigation hose of the invention is made from a continuous strip of flexible, water impervious plastic film, generally ranging in thickness between 4 and 15 mil. As depicted by block 10 in FIG. 1, outlets and/or inlets are formed in the strip of film along one margin. As described in more detail below, each outlet and/or inlet comprises a single longitudinal slit in the film. Next, as depicted by block 12, two molten plastic beads made of material compatible with the film are deposited by an extruder on the margin of

the film on either side of the outlet slits. Next, as depicted by block 14, the track pattern of the ribs is formed in the molten beads by a rib forming wheel. The track pattern is repeated each time the rib forming wheel completes a revolution. As depicted by block 16, after the ribs are formed, the margins of the film are overlapped to position between them the track pattern. Finally, as depicted by block 18, the overlapping margins are sealed by the still molten ribs to form the finished hose. The described steps, except for formation of the outlets and/or inlets, are shown in more detail in the referenced '984 patent. Alternatively, either the inlets or the outlets could be formed as interruptions in one of the ribs.

FIG. 2 illustrates the path of a continuous strip of film 38 from which the drip irrigation hose is made between the formation of the outlets and/or inlets (block 10) and the formation of the track pattern (block 14). An outlet forming wheel 20 and a rib forming wheel 22 are mounted on a common shaft 24 to synchronize their operation. Wheels 20 and 22 have the same diameter. A backing wheel 26 engages outlet forming wheel 20 to establish a nip 28 therebetween. A knife blade 30 is mounted on the periphery of wheel 20. Wheel 26 has a circumferential slot 32 into which knife blade 30 fits at nip 28. Direction changing wheels 34 and 36 also define part of the film path. Wheels 20, 22, 26, 34, and 36 have flanges to guide film 38 laterally during the manufacturing operation.

Wheel 22 has, around its periphery, impressions (not shown) that define the desired track pattern, for example, one of the track patterns is shown in the '051 patent or in the '739 patent. The direction of movement of film 38 is depicted by the arrows in FIG. 2. Film 38 is wrapped around wheel 26 to reverse direction and pass into nip 28. As a result, a slit is formed in film 38 each time blade 30 passes into nip 28. A slit is formed each time wheel 20 completes one revolution. After leaving wheel 26, film 38 is wrapped around wheel 34 to reverse direction and return toward wheel 20. Film 38 is wrapped around a portion of the periphery of wheel 20, spaced laterally from knife blade 30, to reverse direction. After leaving wheel 20, film 38 is wrapped around wheel 36 to reverse direction and move toward wheel 22. Wheel 36 could be canted slightly to provide a smooth transition in the film path between wheels 20 and 22, and the film could twist slightly between wheels 36 and 22. Between wheels 36 and 22, film 38 passes under an extruder 40 which deposits one or more molten plastic beads on one margin of film 38. A backing wheel (not shown) underlies wheel 22 to form a nip through which film 38 passes to form the molten beads. Since wheels 20 and 22 are mounted on a common shaft, the formation of the outlets and the track pattern is coordinated and their relative positioning is closely controlled. After leaving wheel 22, film 38 is finished in the manner illustrated in FIG. 5 of the '984 patent. In a typical embodiment, the diameters of wheels 20 and 22 would be about from 3 to 6 inches, the diameter of wheel 26 would be about 4 inches, the diameters of wheels 34 and 36 would be about 4 inches, and the distance between wheels 22 and 36 would be about 24 inches.

If the inlets also comprise slits another knife blade is mounted on the periphery of wheel 20 laterally spaced from knife blade 30 and wheel 26 has another circumferential slot laterally spaced from slot 32 into which the other knife blade fits. The inlets as well as the outlets are formed as the respective knife blades pass into nip 28.

FIG. 3 illustrates an alternative film path arrangement that permits wheels 20 and 22 to have different diameters so that the outlet spacing can be greater than the track pattern length, which produces a skip in the outlet configuration. Wheel 20 and a toothed wheel 50 are mounted on a shaft 52. Wheel 22 and a toothed wheel 54 are mounted on a shaft 56. A toothed belt 58 couples wheels 50 and 54 to synchronize the rotation of wheels 20 and 22 in a ratio to cause the desired skip in the outlet spacing relative to the track pattern length. In short toothed wheels 50 and 54 and toothed belt 58 replace shaft 24 in the embodiment of FIG. 2. The diameters of wheels 20, 22, 50, and 54 are selected so the angular velocity of wheel 22 is a multiple of the angular velocity of wheel 20, depending upon the desired outlet skip. As a result, the same rib forming wheel 22 can be used to produce a variety of outlet spacings, i.e., skipped outlet configurations.

In FIG. 4, the completed drip irrigation hose is shown. Strip 38 is bent along its length to form an overlapping longitudinal seam between an interior margin and an exterior margin of the strip. Spaced apart, transverse ribs 42 and 43 extend longitudinally through the seam to connect the margins of strip 38, forming a seal and a flow regulating passage 44 therebetween. A water supply passage 45, having a much larger cross-section area then flow regulating passage 44 is defined by the remainder of strip 38. Longitudinally spaced apart slits 46 in the portion of strip 38 between supply passage 45 and flow regulating passage 44 serve as inlets to flow regulating passage 44. Longitudinally spaced apart slits 47, formed in the exterior margin of strip 38, serve as outlets from the hose. Slits 47 are displaced from the respective slits 46 to provide a substantial path length from each inlet to a respective outlet. Preferably, cross ribs 48 are employed to divide the flow regulating passage into segments, such that slit 46 is at one end of the segment and a slit 47 is at the other end of a segment. Alternatively, the inlets could be formed by interruptions in rib 42 as illustrated in FIGS. 5 and 6 of the '051 patent and as illustrated in the '739 patent. The shape of ribs 42, 43 and 48 are determined by the track pattern on wheel 22 (FIG. 2). Preferably, chevrons are formed on the adjacent interior surfaces of ribs 42 and 43 to create turbulent flow in the flow regulating passage as illustrated in the '739 patent.

By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. Typically, the line pressure of the water used for crop irrigation ranges from about 4 psig to 14 psig. Slits 47 are sufficiently long and strip 38 is sufficiently flexible so the water drips from the outlets when the hose is pressurized, rather than squirting. The effective area of the outlets remains small because the material on both sides of the slits remain in the same plane, rather than buckling. If the slits are too short or the strip is too rigid, the material on either side of the slits does not move sufficiently to make a large hole when the hose is pressurized and water squirts out the hose and erodes the soil. Slits 47 are sufficient short and strip 38 is sufficiently rigid so the outlets close completely when the hose is depressurized. If the slits are too long or the strip is too flexible, the slits do not close when the hose is depressurized. Typically, the slits are about ¼ inch for a 4 mil film thickness and the slits are about ⅜ inch for a 15 mil film thickness. Thus, if the slits are much shorter than about ¼ inch for a 4 mil film thickness or if the film is much thicker than about 4 mil for a slit length of about ¼ inch, the water may squirt from the outlets. Similarly, if the slits are much longer than about ⅜ inch for a 15 mil film thickness or if the film is much thinner than about 15 mil for a slit length of about ⅜ inch, the outlets may not close after the hose is depressurized.

Despite the foregoing, it has recently been discovered that with a slit length of almost one inch, the outlets still close after the hose is depressurized if the film is flexible enough.

Exhibit: 1
Page: 31

The described embodiment of the invention is only considered to be preferred and illustrative of the inventive concept; the scope of the invention is not to be restricted to such embodiments. Various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of this invention.

What is claimed is:

1. A drip irrigation hose comprising:

an elongated plastic hose that provides a large water supply passage;

a small flow regulating passage extending along the length of the hose;

a plurality of longitudinally spaced inlet ports to the flow regulating passage from the water supply passage;

a plurality of longitudinally spaced outlet ports from the flow regulating passage to the exterior of the hose, the outlet ports being displaced from the respective inlet ports to provide a substantial path length from each inlet port through the flow regulating passage to a respective outlet port,

wherein each port of one type comprises a single longitudinal, knife blade formed slit.

2. The drip irrigation hose of claim 1, in which the elongated hose comprises an elongated flexible strip of plastic film bent along its length to form a lapped longitudinal seam between opposing longitudinal margins of the film and means for interconnecting the opposing margins along their length to seal the overlapping longitudinal seam and form thereby the elongated hose.

3. The drip irrigation hose of claim 2, in which the flow regulating passage is located at the seal of the overlapping seam.

4. The hose of claim 1, in which each port of the one type is an outlet port.

5. The hose of claim 1, in which each port of the one type is an inlet port.

6. The hose of claim 1, in which the slits are sufficiently long and the strip is sufficient flexible so the water drips from the port when the hose is pressurized, and the slits are sufficiently short and the strip is sufficiently rigid so the slits close completely when the hose is depressurized.

* * * * *

Exhibit: C

Page: 32

US006464816B1

(12) **United States Patent**
DeFrank et al.

(10) **Patent No.: US 6,464,816 B1**
(45) **Date of Patent: *Oct. 15, 2002**

(54) **METHOD AND APPARATUS FOR MAKING A DRIP IRRIGATION HOSE**

(75) Inventors: **Michael DeFrank**, Temecula; **David Marchetti**; **David L. Teegardin**, both of San Diego, all of CA (US)

(73) Assignee: **T-Systems International, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/128,770**

(22) Filed: **Aug. 4, 1998**

Related U.S. Application Data

(62) Division of application No. 08/850,407, filed on May 2, 1997, now Pat. No. 5,865,377, which is a continuation-in-part of application No. 08/650,464, filed on May 20, 1996, now Pat. No. 5,634,595, which is a continuation of application No. 08/279,813, filed on Jul. 19, 1994, now Pat. No. 5,522,551.

(51) **Int. Cl.**[7] **B29C 53/48**; B05B 15/00
(52) **U.S. Cl.** **156/203**; 156/252; 156/466; 156/513
(58) **Field of Search** 156/203, 252, 156/466, 513; 239/542, 533.13

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,004,041	A *	6/1935	Driver	156/203
3,320,109	A *	5/1967	Bruner	156/252
3,532,586	A *	10/1970	Haurey et al.	156/252
3,899,135	A	8/1975	O'Brien	
4,053,109	A	10/1977	Gilead	
4,139,159	A *	2/1979	Inuoue et al.	239/547

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE	A 2508865	9/1976
JP	53-107940	9/1978

OTHER PUBLICATIONS

Letter from Michael J. Kennan, Esq., of the law firm of Nixon & Vanderhye P.C., regarding U.S. Patent No. 5,865,377, two pages, May 3, 1999.

Hardie Irrigation Product Information Sheet.

IL 46,345; Dec. 1974.

IL 50,051; Nov. 1979.

IL 52, 184; May 1977.

Primary Examiner—Michael W. Ball
Assistant Examiner—Barbara J. Musser
(74) *Attorney, Agent, or Firm*—Christie, Parker & Hale, LLP

(57) **ABSTRACT**

A drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized. An outlet forming wheel has a knife blade on its periphery. A backing wheel engages the outlet forming wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. The outlet forming wheel and the rib forming wheel are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in a path that reverses direction four times to accommodate these wheels.

29 Claims, 5 Drawing Sheets

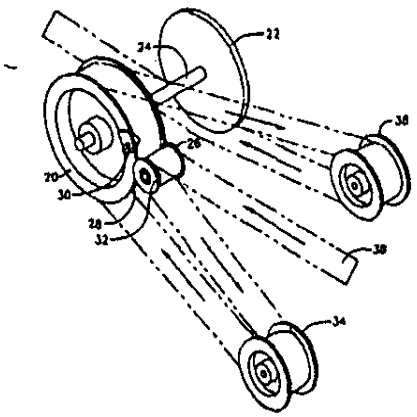


Exhibit: D
Page: 33

U.S. PATENT DOCUMENTS

4,195,784	A *	4/1980	Gilead	239/542
4,247,051	A	1/1981	Allport	
4,548,360	A	10/1985	Delmer et al.	
4,572,452	A	2/1986	Driscoll et al.	
4,642,152	A	2/1987	Chapin	
4,779,800	A	10/1988	Tuomi	
4,850,947	A	7/1989	Brown et al.	
4,859,264	A	8/1989	Buluschek	
4,984,739	A	1/1991	Allport	
5,123,984	A	6/1992	Allport et al.	
5,375,770	A	12/1994	Roberts	
5,584,952	A	12/1996	Rubenstein et al.	
5,806,188	A	9/1998	Caraballo	

* cited by examiner

Exhibit: D
Page: 34

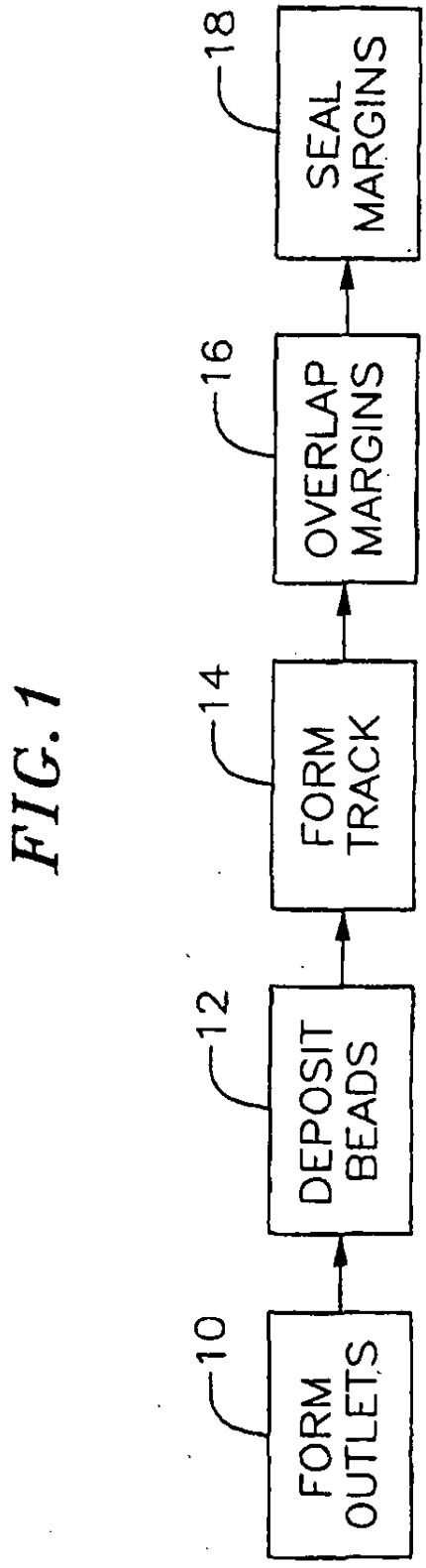


FIG. 1

Exhibit: D

Page: 35

FIG. 2

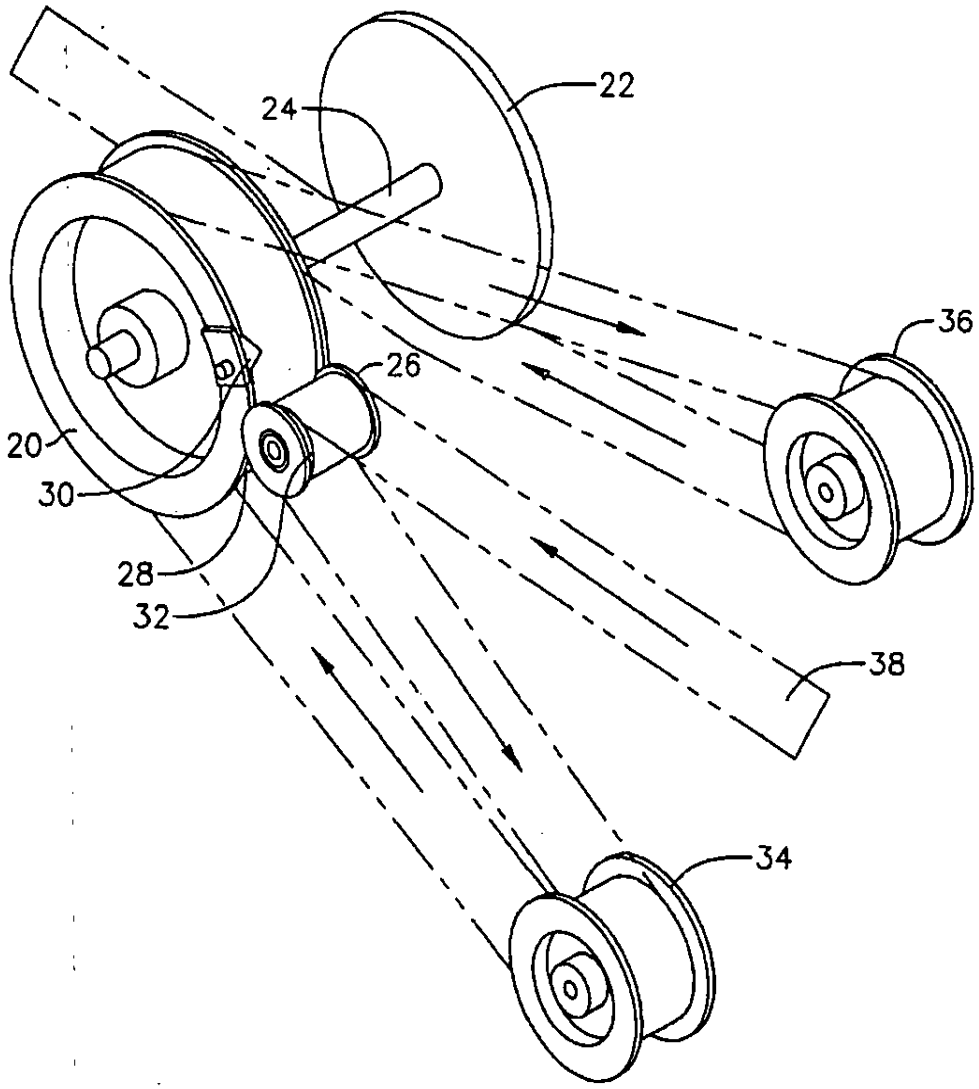


Exhibit: D

Page: 36

FIG.3

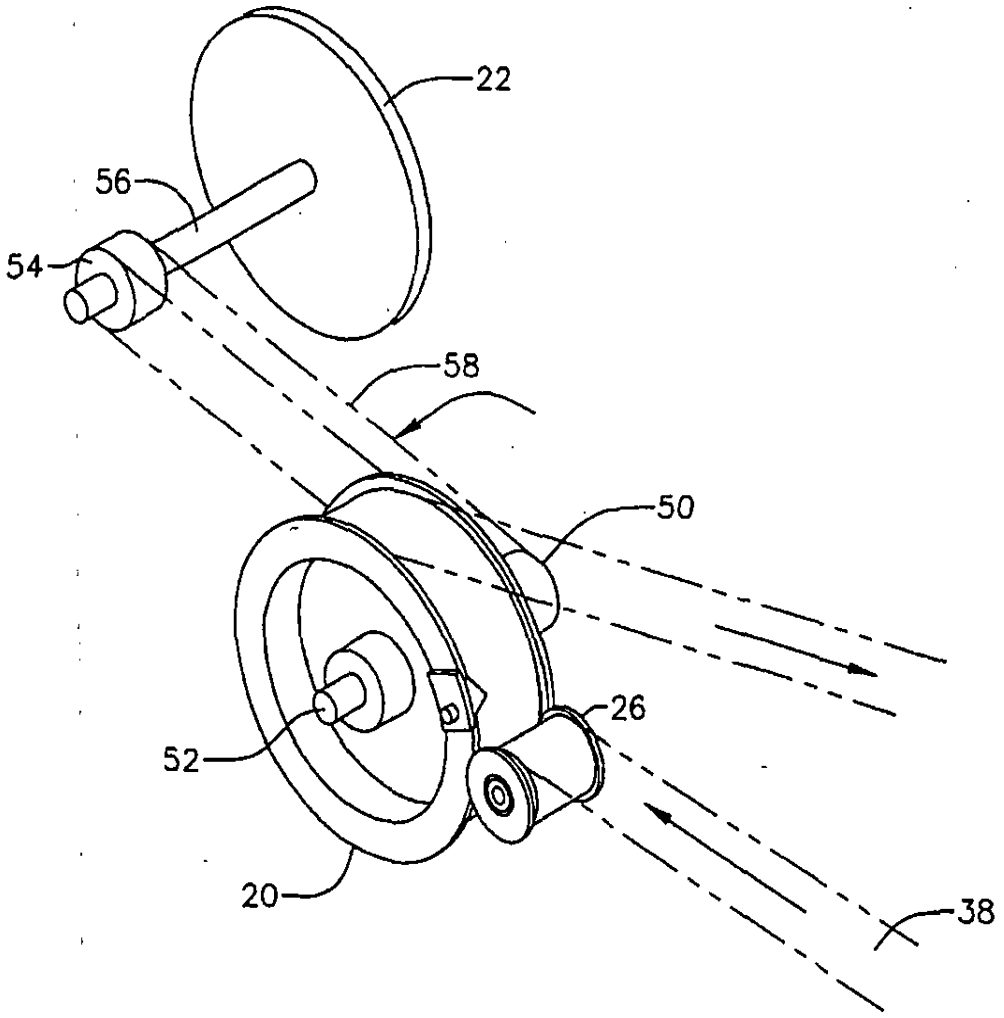


Exhibit: D

Page: 37

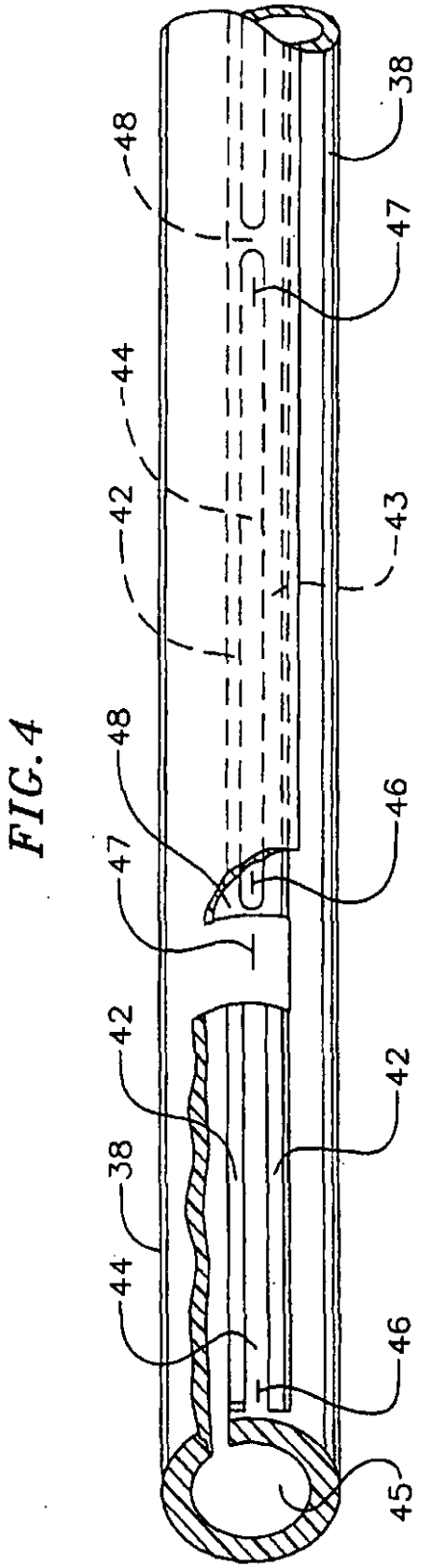


FIG. 4

Exhibit: D
Page: 38

FIG.5

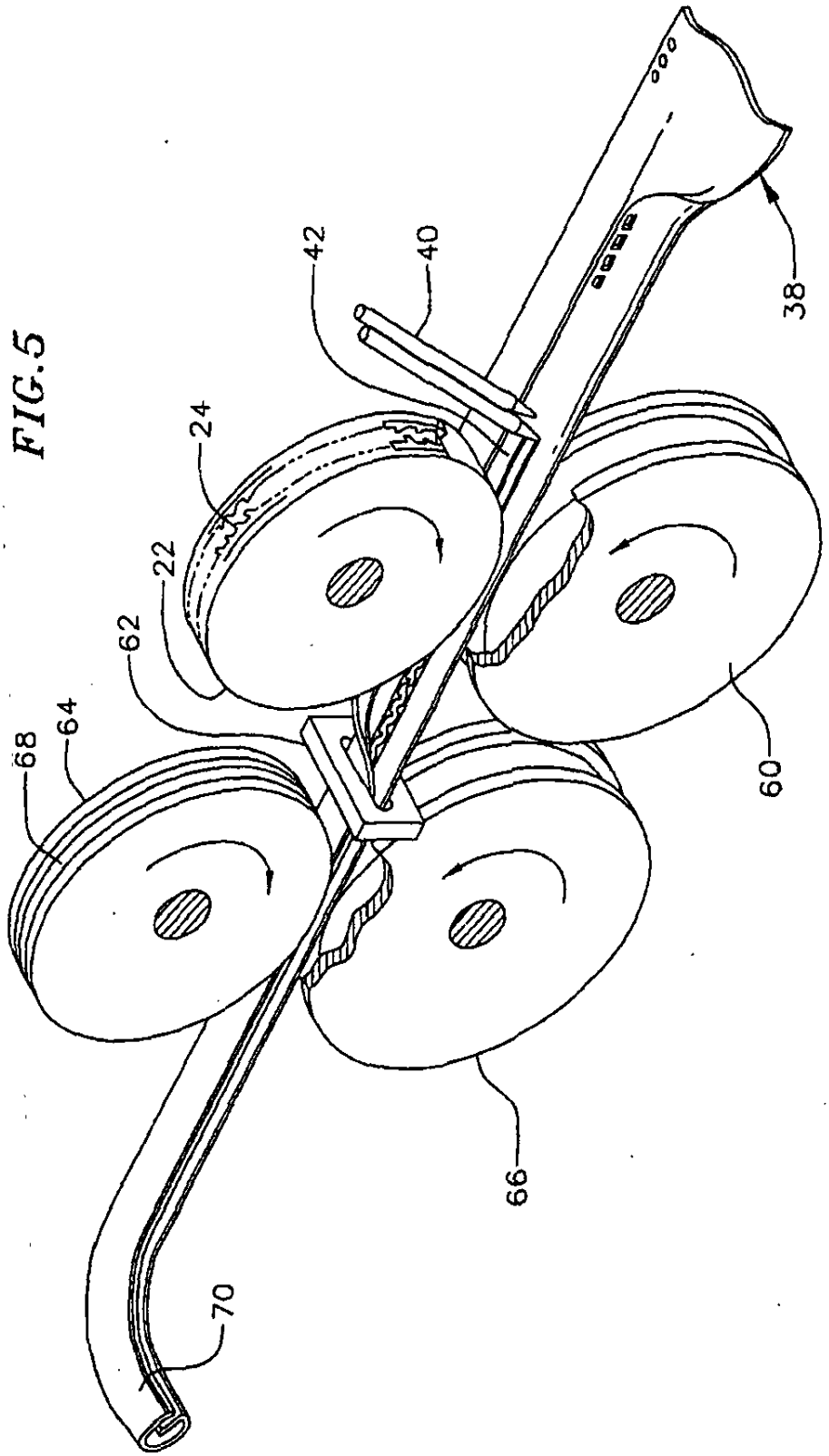


Exhibit D.
Page: 39

METHOD AND APPARATUS FOR MAKING A DRIP IRRIGATION HOSE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of application Ser. No. 08/850,407, filed May 2, 1997, now U.S. Pat. No. 5,865,377, which is a continuation-in-part of application Ser. No. 08/650,469 filed May 20, 1996, now U.S. Pat. No. 5,634,595 now allowed, which is a continuation of Application Ser. No. 08/279,813 filed Jul. 19, 1994, which issued as U.S. Pat. No. 5,552,551 on Jun. 4, 1996.

BACKGROUND OF THE INVENTION

This invention relates to drip irrigation and, more particularly, to a drip irrigation hose with an improved outlet construction and a method for its manufacture.

Drip irrigation hose can be classified into two types—hose having discrete emitters and hose having continuous, integral emitters. An example of a drip irrigation hose having discrete emitters is shown in U.S. Pat. No. 4,850,531. An example of a drip irrigation hose continuous, integral emitters is shown in U.S. Pat. No. 4,247,051. Drip irrigation hose having continuous integral emitters offers the possibility of lower cost and ease of manufacture and installation.

The design of the inlets to and outlets from the emitters is critical. If the effective outlet area of the emitters is too large, dirt and debris can collect externally in the outlets, thereby causing external clogging. If the effective inlet and outlet areas of the emitters are too small, they become clogged internally and cease to serve their purpose. Further, if the effective outlet areas of the emitters are too small, water squirts out of the hose instead of dripping, and soil erosion results.

U.S. Pat. No. 4,247,051 discloses a drip irrigation hose formed by bending a strip plastic film along its length to form an overlapping longitudinal seam between opposing longitudinal margins of the film. First and second longitudinally extending, laterally spaced, transverse ribs interconnect the opposing margins along their length to seal the overlapping longitudinal seam. The ribs are formed by one or more molten plastic beads extruded onto the film. As a result, a flow regulating passage is defined by the ribs and the opposing margins and a supply passage is defined by the remainder of the film. Water flows from the supply passage to the flow regulating passage through a plurality of longitudinally spaced inlets. Water flows from the flow regulating passage to the exterior of the hose through a plurality of longitudinally spaced outlets longitudinally spaced from the respective inlets to provide a substantial path length from each inlet to a respective outlet. In one embodiment, the outlets each comprise two parallel slits that form between them a flexible flap. The flap serves as an outlet valve, opening and closing as the hose is pressurized and depressurized. However, unless the plastic film is very thick and rigid, the flaps do not close consistently when the hose is depressurized and therefore, the outlets can become clogged by soil drawn into the slits.

A problem encountered in the manufacture of continuous emitter drip irrigation hose is coordinating the position of the outlets and the track pattern of the ribs. If care is not taken, the track pattern of the ribs may overlap the outlets, and thereby cause the outlets to be on the high pressure side of the flow regulating passages.

SUMMARY OF THE INVENTION

One aspect of the invention is a drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized.

Another aspect of the invention is a method for making a drip irrigation hose having longitudinal single slit outlets and/or inlets. A first outlet and/or inlet forming wheel has one or more knife blades on its periphery. A second backing wheel engages the first wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A third rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. A second nip is established with a third wheel in which the desired track pattern is formed. The first and second wheels are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in the following path in the order recited. The film is wrapped around the second wheel to reverse direction and pass into the first nip, thereby forming the outlet slits. The direction of the film is reversed leaving the first nip to transport the film toward the first wheel. The film is wrapped around a portion of the periphery of the first wheel spaced laterally from the knife blade to reverse direction. The direction of the film is reversed to transport the film toward the third wheel. The film is transported under an extruder to deposit a bead of molten plastic on the film before the third wheel. The film is transported into the second nip to form the desired track in the molten plastic. After the film leaves the third wheel, the hose is finished. The described method forms the outlet slits and the track pattern in a coordinated fashion. As a result, the outlets are not restricted or plugged by the ribs.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of specific embodiments of the best mode contemplated of carrying out the invention are illustrated in the drawings, in which:

FIG. 1 is a schematic block diagram of the method for making a drip irrigation hose of the continuous emitter type;

FIG. 2 is a schematic view of a portion of the film path for making a drip irrigation hose in accordance with the invention;

FIG. 3 is a schematic view of a portion of the film path in an alternative embodiment to the film path of FIG. 2; and

FIG. 4 is a side partially cutaway view of a length of drip irrigation hose incorporating the principals of the invention; and

FIG. 5 is a schematic diagram of apparatus for completing the manufacture of a drip irrigation hose following the operations shown in FIG. 2.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

The disclosures of U.S. Pat. Nos. 4,247,051, 4,984,739 and 5,123,984 are incorporated fully herein by reference.

The drip irrigation hose of the invention is made from a continuous strip of flexible, water impervious plastic film, generally ranging in thickness between 4 and 15 mil. As depicted by block 10 in FIG. 1, outlets and/or inlets are formed in the strip of film along one margin. As described

Exhibit D

Page: 40

in more detail below, each outlet and/or inlet comprises a single longitudinal slit in the film. Next as depicted by block 12, two molten plastic beads made of material compatible with the film are deposited by an extruder on the margin of the film on either side of the outlet slits. Next, as depicted by block 14, the track pattern of the ribs is formed in the molten beads by a rib forming wheel. The track pattern is repeated each time the rib forming wheel completes a revolution. As depicted by block 16, after the ribs are formed, the margins of the film are overlapped to position between them the track pattern. Finally, as depicted by block 18, the overlapping margins are sealed by the still molten ribs to form the finished hose. The described steps, except for formation of the outlets and/or inlets, are shown in more detail in the referenced '984 patent. Alternatively, either the inlets or the outlets could be formed as interruptions in one of the ribs.

FIG. 2 illustrates the path of a continuous strip of film 38 from which the drip irrigation hose is made between the formation of the outlets and/or inlets (block 10) and the formation of the track pattern (block 14). An outlet forming wheel 20 and a rib forming wheel 22 are mounted on a common shaft 24 to synchronize their operation. Wheels 20 and 22 have the same diameter. A backing wheel 26 engages outlet forming wheel 20 to establish a nip 28 therebetween. A knife blade 30 is mounted on the periphery of wheel 20. Wheel 26 has a circumferential slot 32 into which knife blade 30 fits at nip 28. Direction changing wheels 34 and 36 also define part of the film path. Wheels 20, 22, 26, 34, and 36 have flanges to guide film 38 laterally during the manufacturing operation.

Wheel 22 has, around its periphery, impressions that define the desired track pattern 24, for example, one of the track patterns shown in the '051 patent or in the '739 patent. The direction of movement of film 38 is depicted by the arrows in FIG. 2. Film 38 is wrapped around wheel 26 to reverse direction and pass into nip 28. As a result, a slit is formed in film 38 each time blade 30 passes into nip 28. A slit is formed each time wheel 20 completes one revolution. After leaving wheel 26, film 38 is wrapped around wheel 34 to reverse direction and return toward wheel 20. Film 38 is wrapped around a portion of the periphery of wheel 20, spaced laterally from knife blade 30, to reverse direction. After leaving wheel 20, film 38 is wrapped around wheel 36 to reverse direction and move toward wheel 22. Wheel 36 could be canted slightly to provide a smooth transition in the film path between wheels 20 and 22, and the film could twist slightly between wheels 36 and 22. Between wheels 36 and 22, film 38 passes under an extruder 40 which deposits one or more molten plastic beads on one margin of film 38. Since wheels 20 and 22 are mounted on a common shaft, the formation of the outlets and the track pattern is coordinated and their relative positioning is closely controlled. After leaving wheel 22, film 38 is finished in the manner illustrated in FIG. 5. More specifically, as film 38 approaches extruder 40, its inner margin is folded over and extruder 40 forms one or more beads 42 on the exposed surface of the inner margin of film 38. A backing wheel 60 underlies wheel 22, which has track pattern 24. After passage through the nip formed by wheels 22 and 60, the outer margin of film 38 is folded by a guide 62 to overlap the inner margin of film 38. The folded film 38 then passes through the nip of a form wheel 64 and a backing wheel 66. Form wheel 64 has a groove 68 that depresses the beads to set the bead height at a specified value. The value of the bead height determines the flow rate of the hose. A finished hose 70 leaves the nip between wheels 66 and 68. In a typical embodiment, the diameters of wheels 20 and 22 would be about from 3 to 6 inches, the diameter of wheel 26 would be about 4 inches, the diameters of wheels 34 and 36 would be about 4 inches, and the distance between wheels 22 and 36 would be about 24 inches.

If the inlets also comprise slits another knife blade is mounted on the periphery of wheel 20 laterally spaced from knife blade 30 and wheel 26 has another circumferential slot laterally spaced from slot 32 into which the other knife blade fits. The inlets as well as the outlets are formed as the respective knife blades pass into nip 28.

FIG. 3 illustrates an alternative film path arrangement that permits wheels 20 and 22 to have different diameters so that the outlet spacing can be greater than the track pattern length, which produces a skip in the outlet configuration. Wheel 20 and a toothed wheel 50 are mounted on a shaft 52. Wheel 22 and a toothed wheel 54 are mounted on a shaft 56. A toothed belt 58 couples wheels 50 and 54 to synchronize the rotation of wheels 20 and 22 in a ratio to cause the desired skip in the outlet spacing relative to the track pattern length. In short toothed wheels 50 and 54 and toothed belt 58 replace shaft 24 in the embodiment of FIG. 2. The diameters of wheels 20, 22, 50, and 54 are selected so the angular velocity of wheel 22 is a multiple of the angular velocity of wheel 20, depending upon the desired outlet skip. As a result, the same rib forming wheel 22 can be used to produce a variety of outlet spacings, i.e., skipped outlet configurations.

In FIG. 4, the completed drip irrigation hose is shown. Strip 38 is bent along its length to form an overlapping longitudinal seam between an interior margin and an exterior margin of the strip. Spaced apart, transverse ribs 42 and 43 extend longitudinally through the seam to connect the margins of strip 38, forming a seal and a flow regulating passage 44 therebetween. A water supply passage 45, having a much larger cross-section area than flow regulating passage 44 is defined by the remainder of strip 38. Longitudinally spaced apart slits 46 in the portion of strip 38 between supply passage 45 and flow regulating passage 44 serve as inlets to flow regulating passage 44. Longitudinally spaced apart slits 47, formed in the exterior margin of strip 38, serve as outlets from the hose. Slits 47 are displaced from the respective slits 46 to provide a substantial path length from each inlet to a respective outlet. Preferably, cross ribs 48 are employed to divide the flow regulating passage into segments, such that slit 46 is at one end of the segment and a slit 47 is at the other end of a segment. Alternatively, the inlets could be formed by interruptions in rib 42 as illustrated in FIGS. 5 and 6 of the '051 patent and as illustrated in the '739 patent. The shape of ribs 42, 43 and 48 are determined by the track pattern on wheel 22 (FIG. 2). Preferably, chevrons are formed on the adjacent interior surfaces of ribs 42 and 43 to create turbulent flow in the flow regulating passage as illustrated in the '739 patent.

By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. Typically, the line pressure of the water used for crop irrigation ranges from about 4 psig to 14 psig. Slits 47 are sufficiently long and strip 38 is sufficiently flexible so the water drips from the outlets when the hose is pressurized, rather than squirting. The effective area of the outlets remains small because the material on both sides of the slits remain in the same plane, rather than buckling. If the slits are too short or the strip is too rigid, the material on either side of the slits does not move sufficiently to make a large hole when the hose is pressurized and water squirts out the hose and erodes the soil. Slits 47 are sufficient short and strip 38

is sufficiently rigid so the outlets close completely when the hose is depressurized. If the slits are too long or the strip is too flexible, the slits do not close when the hose is depressurized. Typically, the slits are about ¼ inch for a 4 mil film thickness and the slits are about ⅛ inch for a 15 mil film thickness. Thus, if the slits are much shorter than about ¼ inch for a 4 mil film thickness or if the film is much thicker than about 4 mil for a slit length of about ¼ inch, the water may squirt from the outlets. Similarly, if the slits are much longer than about ⅛ inch for a 15 mil film thickness or if the film is much thinner than about 15 mil for a slit length of about ⅛ inch, the outlets may not close after the hose is depressurized.

Despite the foregoing, it has recently been discovered that with a slit length of almost one inch, the outlets still close after the hose is depressurized if the film is flexible enough.

The described embodiment of the invention is only considered to be preferred and illustrative of the inventive concept; the scope of the invention is not to be restricted to such embodiments. Various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of this invention.

What is claimed is:

1. A method for making drip irrigation hose comprising:

rotating an outlet forming wheel having a knife blade on its periphery;

maintaining a continuous moving strip of plastic film having first and second longitudinal margins in contact with the wheel to form slit outlets repeatedly along the first margin of the strip as the knife blade rotates;

forming an elongated flow regulating passage and inlets to the flow regulating passage on one margin of the strip, the inlets being spaced from the outlets to form a substantial path length from each inlet to outlet;

folding the strip to overlap the first and second margins so the first margin overlies the second margin and the flow regulating passage lies between the overlapping margins; and

sealing the overlapping margins and the flow regulating passage to form a water supply passage, the inlets coupling the water supply passage to the flow regulating passage and the outlets coupling the flow regulating passage to the exterior of the hose.

2. A method for making drip irrigation hose comprising:

rotating an outlet forming wheel having a knife blade on its periphery;

maintaining a continuous moving strip of plastic film having first and second margins in contact with the wheel to form slit outlets repeatedly in the surface of the strip as the knife blade rotates;

forming an elongated flow regulating passage on one margin of the strip;

folding the strip to overlap, close the flow regulating passage, and form a water supply passage;

sealing the overlapping margins; and

repeatedly forming inlets from the water supply passage to the flow regulating passage to form a substantial path length from each inlet to outlet.

3. Apparatus for making drip irrigation hose comprising:

a rotating outlet forming wheel having a knife blade on its periphery capable of forming single slit outlets;

a backing wheel that forms a nip with the outlet forming wheel for maintaining a continuous moving strip of plastic film having first and second margins in contact with the wheel to form single slit outlets repeatedly in the first margin of the strip as the knife blade rotates, wherein the strip has a general direction of movement;

means for forming an elongated flow regulating passage on the first margin of the strip over the outlets;

means for folding the strip to overlap the margins so the flow regulating passage lies between the margins;

means for sealing the overlapping margins to form a water supply passage adjacent to the flow regulating passage; and

means for repeatedly forming inlets from the water supply passage to the flow regulating passage to form a substantial path length from each inlet to outlet.

4. The apparatus of claim 3, in which the means for forming a flow regulating passage comprises means for extruding a bead of molten plastic onto the surface of the strip at one margin, a rotating pattern wheel for repeatedly forming a desired track pattern in the bead, means for coupling the pattern wheel to the outlet forming wheel so the pattern and outlet forming wheels rotate in synchronism, and means for pressing the margins together to form the flow regulating passage.

5. The apparatus of claim 4, in which the coupling means comprises a shaft connected between the pattern and outlet forming wheels.

6. Apparatus for making drip irrigation hose comprising:

a rotating outlet forming wheel having a knife blade on its periphery;

a backing wheel that forms a nip with the outlet forming wheel for maintaining a continuous moving strip of plastic film having first and second longitudinal margins in contact with the wheel to form slit outlets repeatedly along the first margin of the strip as the knife blade rotates, wherein the strip has a general direction of movement;

means for forming an elongated flow regulating passage and inlets to the flow regulating passage on one margin of the strip, the inlets being spaced from the outlets to form a substantial path length from each inlet to outlet;

means for folding the strip to overlap the first and second margins so the first margin overlies the second margin and the flow regulating passage lies between the overlapping margins;

means for sealing the overlapping margins and the flow regulating passage to form a water supply passage, the inlets coupling the water supply passage to the flow regulating passage to form a water supply passage, the inlets coupling the water supply passage to the flow regulating passage and the outlets coupling the flow regulating passage to the exterior of the hose.

7. The apparatus of claim 3, in which the means for forming inlets forms inlets in the second margin.

8. The apparatus of claim 3, in which the means for forming inlets forms slit inlets in the second margin.

9. The apparatus of claim 4, in which the means for forming inlets forms interruptions in the track pattern of the pattern wheel.

10. The apparatus of claim 3, in which the knife blade is mounted on the periphery of the outlet forming wheel.

11. The apparatus of claim 10, in which the backing wheel has a circumferential slot into which the knife blade fits as it passes through the nip.

12. The apparatus of claim 11, in which the strip is wrapped around the backing wheel such that it moves in the general direction of movement before it passes through the nip and opposite the general direction of movement after it passes through the nip.

Exhibit: D

Page: 42

13. The apparatus of claim 12, additionally comprising a direction changing wheel around which the strip is wrapped such that it moves in the general direction of movement after it leaves the direction changing wheel.

14. The apparatus of claim 13, in which the strip is wrapped around the outlet forming wheel after it leaves the direction changing wheel such that the strip moves opposite the general direction of movement after the strip leaves the outlet forming wheel.

15. The apparatus of claim 14, additionally comprising a further direction changing wheel around which the strip is wrapped such that it moves in the general direction of movement after it leaves the further direction changing wheel.

16. The apparatus of claim 3, in which the means for forming a flow regulating passage comprises an extruder that deposits one or more molten beads on the first margin of the strip and a rotating molding wheel having a pattern of depressions that forms the pattern of the flow regulating passage in the one or more beads.

17. The apparatus of claim 16, additionally comprising means for synchronizing the molding wheel to the outlet forming wheel.

18. The apparatus of claim 17, in which the synchronizing means comprises a rotating shaft connecting the molding wheel to the outlet forming wheel.

19. The apparatus of claim 17, in which the synchronizing means comprises a first coupling wheel connected to the molding wheel, a second coupling wheel connected to the outlet forming wheel, and a rotation transmitting belt between the first and second coupling wheels.

20. The apparatus of claim 19, in which the wheels are designed so the angular velocity of the molding wheel is a multiple of the outlet forming wheel.

21. The apparatus of claim 18, in which the molding wheel is laterally displaced from the outlet forming wheel.

22. The apparatus of claim 17, in which the knife blade is mounted on the periphery of the outlet forming wheel.

23. The apparatus of claim 22, in which the backing wheel has a circumferential slot into which the knife blade fits as it passes through the nip.

24. The apparatus of claim 23, in which the strip is wrapped around the backing wheel such that it moves in the general direction of movement before it passes through the nip and opposite the general direction of movement after it passes through the nip.

25. The apparatus of claim 24, additionally comprising a direction changing wheel around which the strip is wrapped such that it moves in the general direction of movement after it leaves the direction changing wheel.

26. The apparatus of claim 25, in which the strip is wrapped around the outlet forming wheel after it leaves the direction changing wheel such that the strip moves opposite the general direction of movement after the strip leaves the outlet forming wheel.

27. The apparatus of claim 26, additionally comprising a further direction changing wheel around which the strip is wrapped such that the strip moves in the general direction of movement into contact with the outlet forming wheel after it leaves the further direction changing wheel.

28. The apparatus of claim 3, in which the strip moves in a given direction while in contact with the outlet forming wheel, the means for forming a flow regulating passage comprises a rotating passage forming wheel, the apparatus additionally comprising a rotating shaft between the wheels to synchronize their rotation, and a film path between the wheels for reversing the direction of movement of the strip between the wheels so the strip moves across the passage forming wheel in the given direction.

29. The apparatus of claim 3, in which the strip moves in a given direction while in contact with the outlet forming wheel, the means for forming a flow regulating passage comprises a rotating passage forming wheel, the apparatus additionally comprising a first coupling wheel connected to the passage forming wheel, a second coupling wheel connected to the outlet forming wheel, a rotation transmitting belt between the first and second coupling wheels synchronize their rotation, and a film path between the wheels for reversing the direction of movement of the strip between the wheels so the strip moves across the passage forming wheel in the given direction.

* * * * *

Exhibit D
Page: 43

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

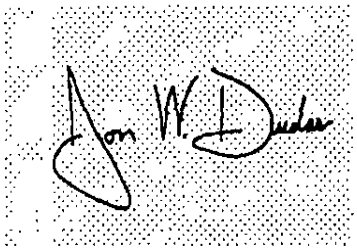
PATENT NO. : 6,464,816 B1
DATED : October 15, 2002
INVENTOR(S) : Michael DeFrank et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 6,
Line 47, after "passage" delete "to form a water supply passage, the inlets coupling the water supply passage to the flow regulating passage".

Signed and Sealed this

Twenty-seventh Day of September, 2005



JON W. DUDAS
Director of the United States Patent and Trademark Office

Exhibit: D
Page: 44

Exhibit E

US006936126B2

(12) **United States Patent**
DeFrank et al.

(10) **Patent No.: US 6,936,126 B2**
(45) **Date of Patent: Aug. 30, 2005**

(54) **METHOD OF MANUFACTURE OF A DRIP IRRIGATION HOSE**

(75) Inventors: **Michael DeFrank**, Temecula, CA (US); **David Marchetti**, San Diego, CA (US); **David L. Teegardin**, San Diego, CA (US)

(73) Assignee: **T-Systems International, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 100 days.

(21) Appl. No.: 10/192,959

(22) Filed: **Jul. 11, 2002**

(65) **Prior Publication Data**

US 2002/0174944 A1 Nov. 28, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/128,770, filed on Aug. 4, 1998, now Pat. No. 6,464,816, which is a division of application No. 08/850,407, filed on May 2, 1997, now Pat. No. 5,865,377, which is a continuation-in-part of application No. 08/650,469, filed on May 20, 1996, now Pat. No. 5,634,595, which is a continuation of application No. 08/279,813, filed on Jul. 19, 1994, now Pat. No. 5,522,551.

(51) Int. Cl.[7] B29C 53/48
(52) U.S. Cl. 156/203; 156/252
(58) Field of Search 156/203, 252, 156/466, 513; 237/542, 533.3; 83/332, 343, 425, 676, 30, 57, 331

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,320,109 A 5/1967 Braner
3,532,586 A 10/1970 Haurey, et al.
3,899,135 A 8/1975 O'Brien

(Continued)

FOREIGN PATENT DOCUMENTS

DE A 2508865 9/1976
JP 53-107940 9/1978

OTHER PUBLICATIONS

Letter from Michael J. Keenan, Esq., of the law firm of Nixon & Vanderhye P.C., regarding U.S. Patent No. 5,865,377, two pages, May 3, 1999.
Hardie Irrigation Product Information Sheet.
IL 46,345; Dec. 1974.
IL 50,051; Nov. 1979.
IL 52,184; May 1977.
IL 52, 184; May 1977.

Primary Examiner—Sam Chuan Yao
Assistant Examiner—Barbara J. Musser
(74) *Attorney, Agent, or Firm*—Christie, Parker & Hale, LLP

(57) **ABSTRACT**

A drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized. An outlet forming wheel has a knife blade on its periphery. A backing wheel engages the outlet forming wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. The outlet forming wheel and the rib forming wheel are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in a path that reverses direction four times to accommodate these wheels.

7 Claims, 5 Drawing Sheets

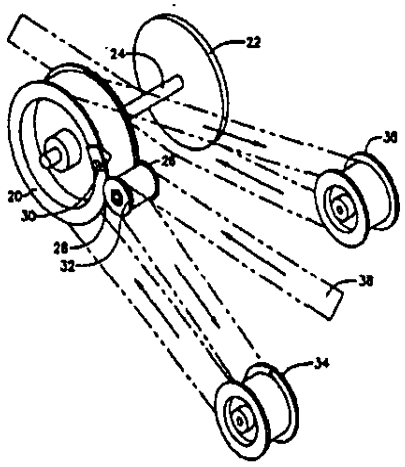


Exhibit: E
Page: 45

U.S. PATENT DOCUMENTS

3,952,637	A *	4/1976	Lambert et al.	493/30
4,053,109	A	10/1977	Gilead	
4,139,159	A	2/1979	Inuoue et al.	
4,167,884	A *	9/1979	Santanna	83/671
4,195,784	A	4/1980	Gilead	
4,204,447	A *	5/1980	Slaughterbeck	83/171
4,247,051	A	1/1981	Allport	
4,548,360	A	10/1985	Delmer et al.	
4,572,452	A	2/1986	Driscoll et al.	
4,642,152	A	2/1987	Chapin	
4,779,800	A	10/1988	Tuomi	
4,850,947	A	7/1989	Brown et al.	
4,859,264	A	8/1989	Buluschek	
4,984,739	A	1/1991	Allport	
5,076,498	A *	12/1991	Townsend	239/542
5,123,984	A	6/1992	Allport et al.	
5,144,874	A *	9/1992	Garrett	83/332
5,375,770	A	12/1994	Roberts	
5,522,551	A *	6/1996	DeFrank et al.	239/542
5,584,952	A	12/1996	Rubenstein et al.	
5,634,595	A *	6/1997	DeFrank et al.	239/542
5,806,188	A	9/1998	Caraballo	
6,464,816	B1 *	10/2002	DeFrank et al.	156/203

* cited by examiner

Exhibit: E

Page: 46

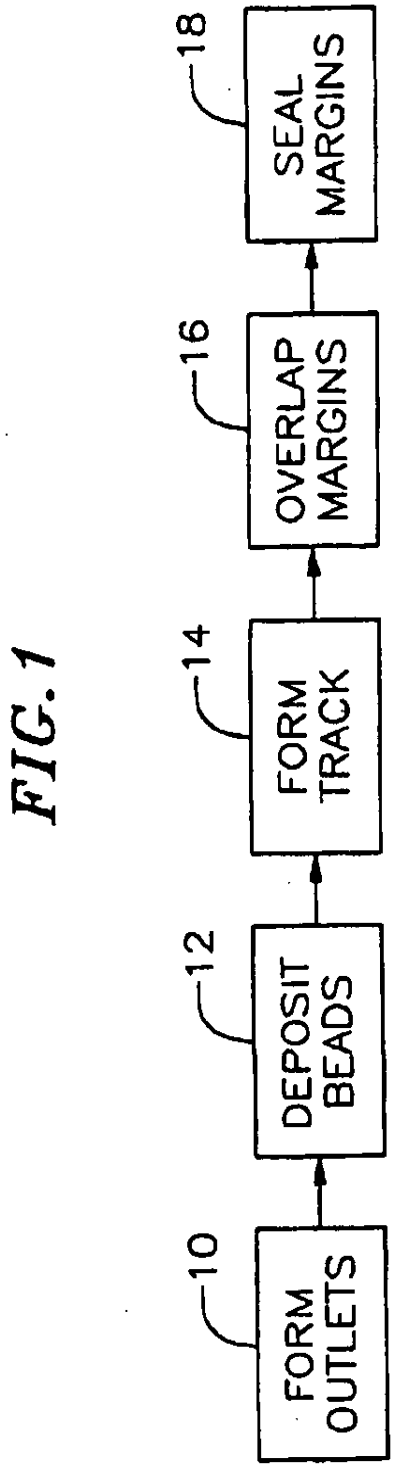


FIG. 1

Exhibit: E
Page: 47

FIG.2

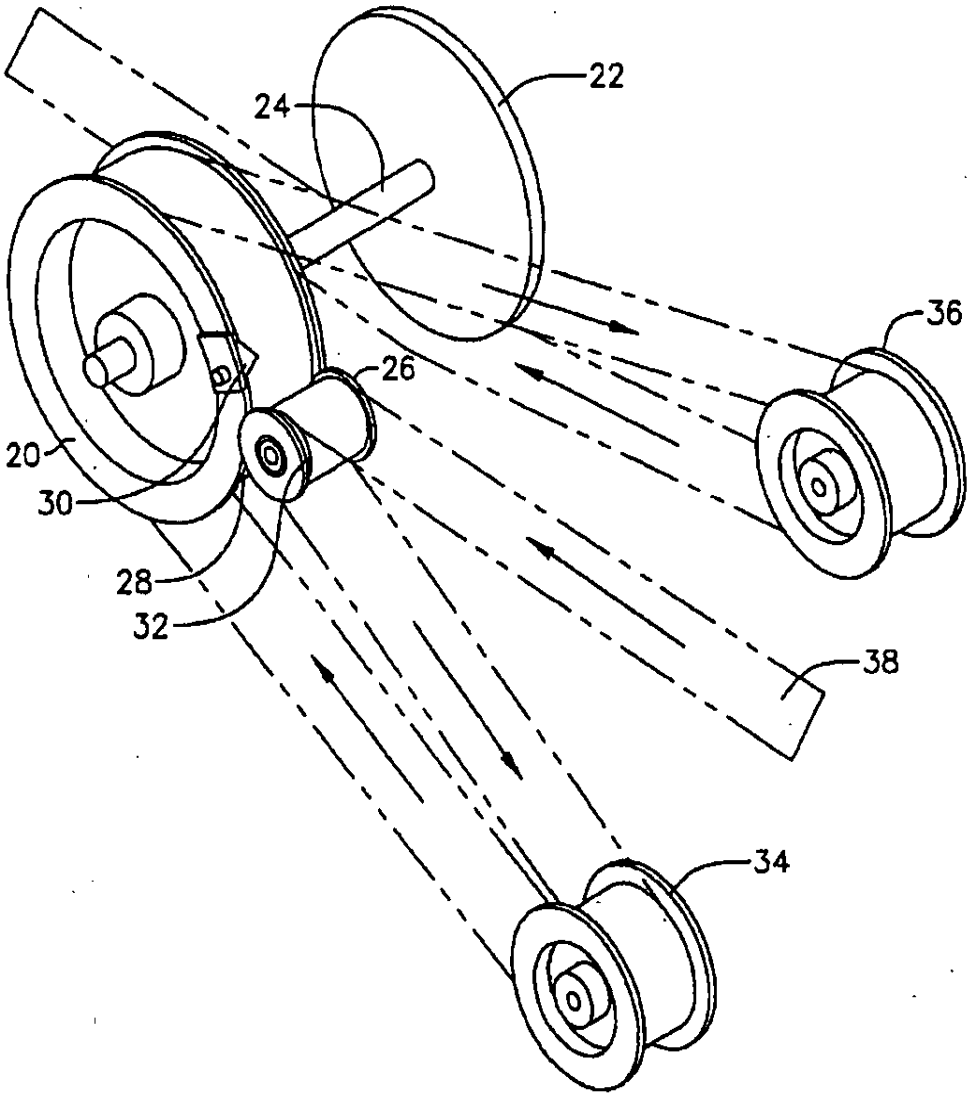


Exhibit: E
Page: 48

FIG. 3

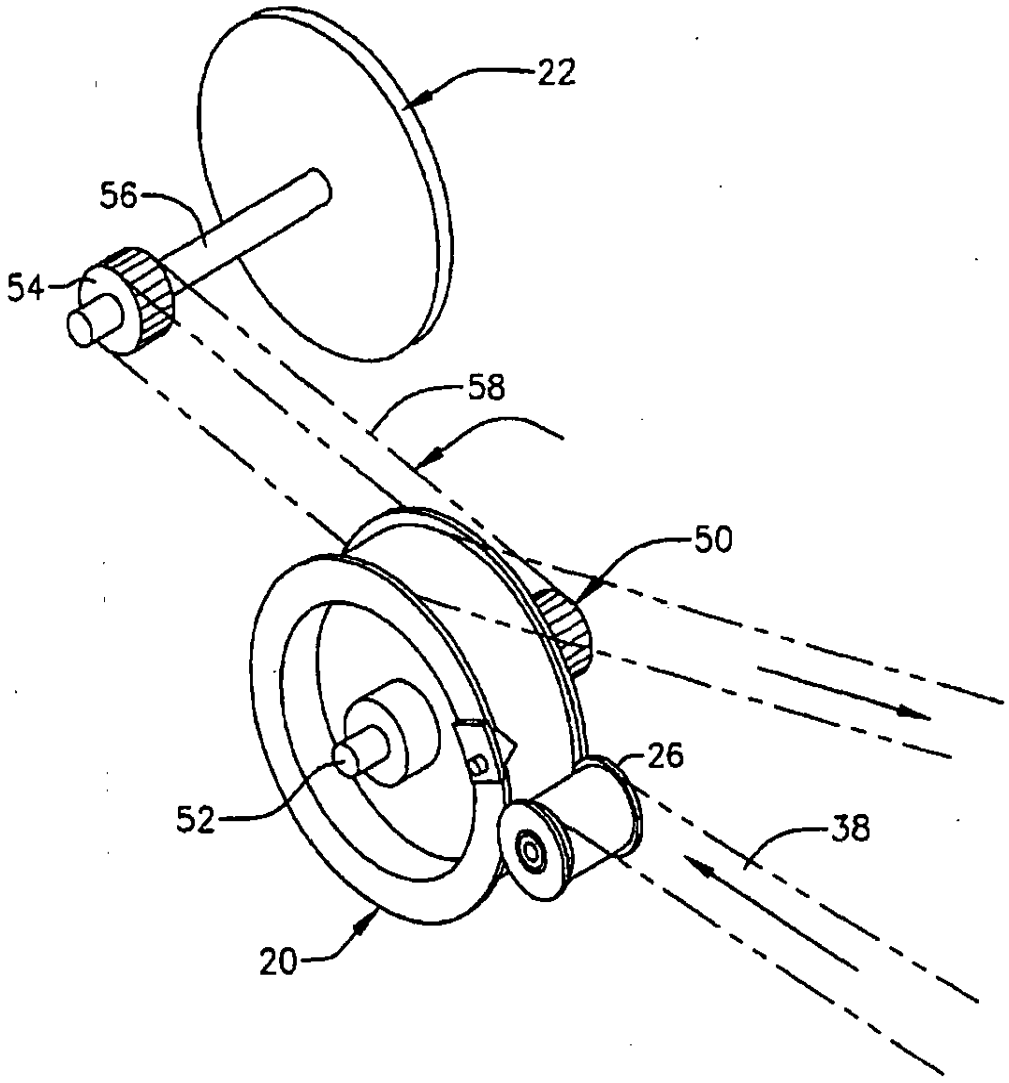


Exhibit: E
Page: 49

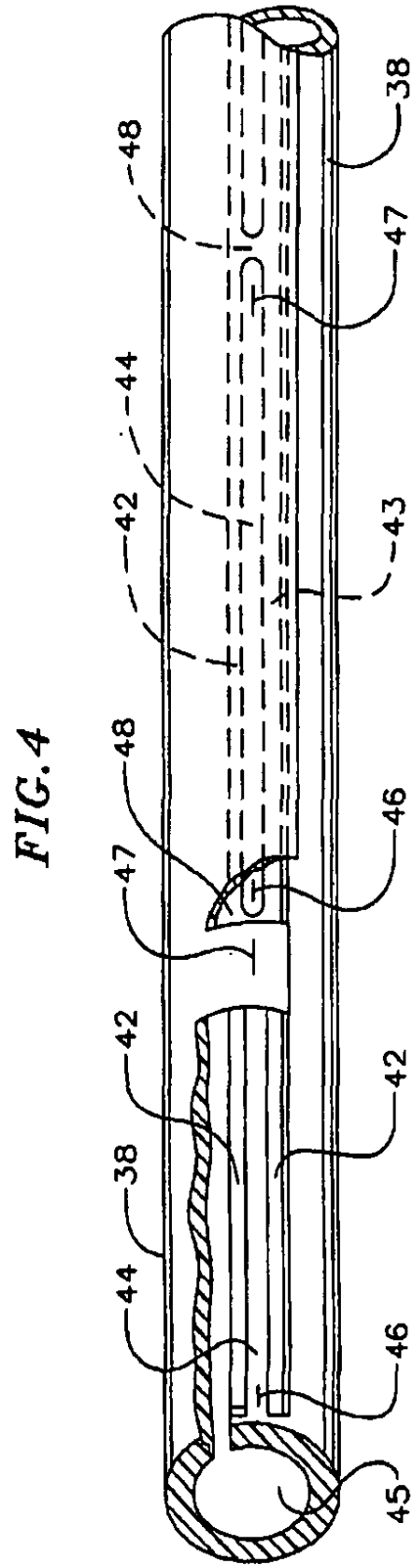


FIG. 4

Exhibit: E

Page: 50

FIG.5

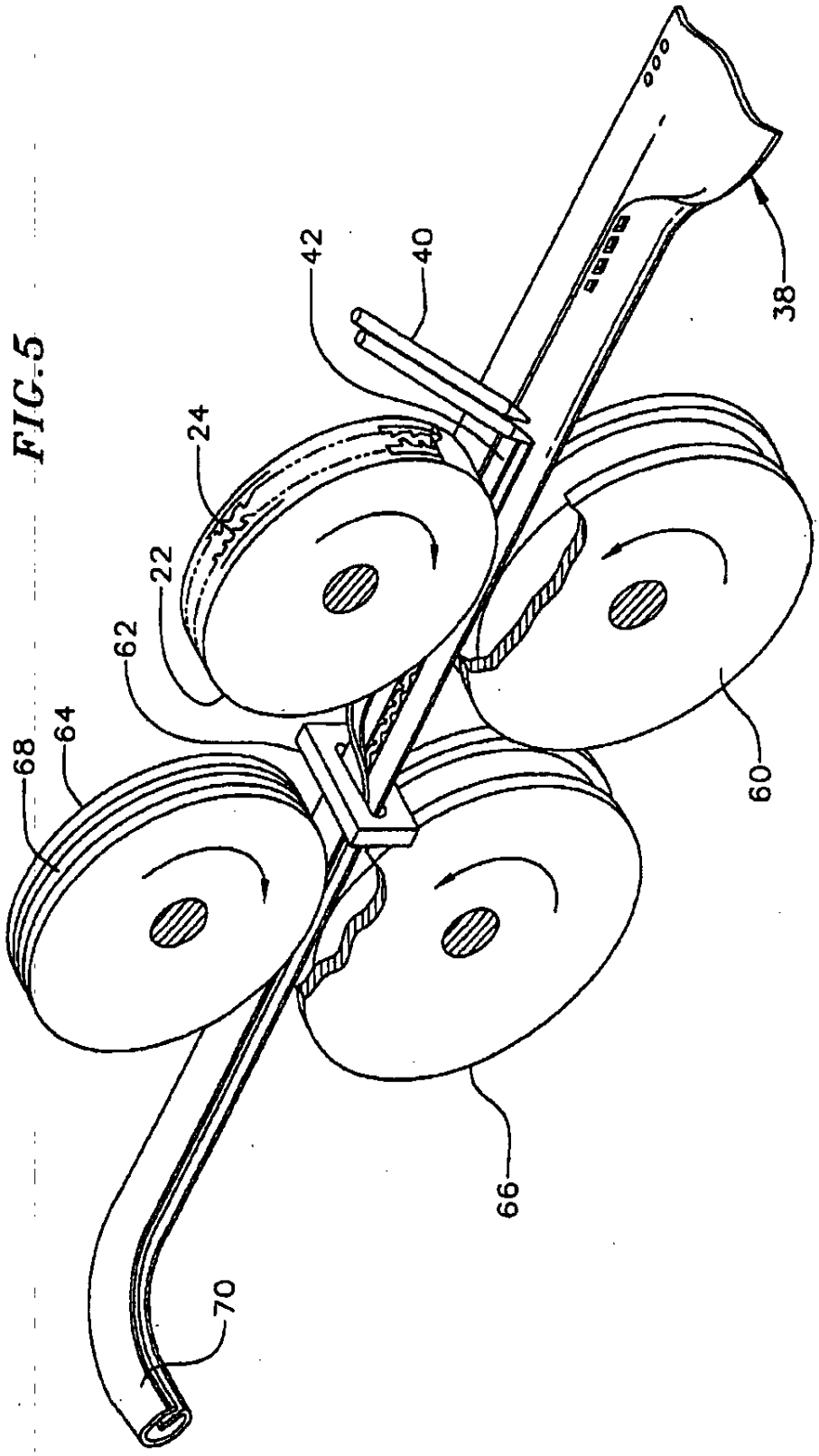


Exhibit E
Page 51

METHOD OF MANUFACTURE OF A DRIP IRRIGATION HOSE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/128,770, filed Aug. 4, 1998, now U.S. Pat. No. 6,464,816, which is a divisional of application Ser. No. 08/850,407, filed May 2, 1997, which issued as U.S. Pat. No. 5,865,377 on Feb. 2, 1999, which is a continuation-in-part of application Ser. No. 08/650,469, filed May 20, 1996, which issued as U.S. Pat. No. 5,634,595 on Jun. 3, 1997, which is a continuation of application Ser. No. 08/279,813, filed Jul. 19, 1994, which issued as U.S. Pat. No. 5,522,551 on Jun. 4, 1996.

BACKGROUND OF THE INVENTION

This invention relates to drip irrigation and, more particularly, to a drip irrigation hose with an improved outlet construction and a method for its manufacture.

Drip irrigation hose can be classified into two types—hose having discrete emitters and hose having continuous, integral emitters. An example of a drip irrigation hose having discrete emitters is shown in U.S. Pat. No. 4,850,531. An example of a drip irrigation hose continuous, integral emitters is shown in U.S. Pat. No. 4,247,051. Drip irrigation hose having continuous integral emitters offers the possibility of lower cost and ease of manufacture and installation.

The design of the inlets to and outlets from the emitters is critical. If the effective outlet area of the emitters is too large, dirt and debris can collect externally in the outlets, thereby causing external clogging. If the effective inlet and outlet areas of the emitters are too small, they become clogged internally and cease to serve their purpose. Further, if the effective outlet areas of the emitters are too small, water squirts out of the hose instead of dripping, and soil erosion results.

U.S. Pat. No. 4,247,051 discloses a drip irrigation hose formed by bending a strip plastic film along its length to form an overlapping longitudinal seam between opposing longitudinal margins of the film. First and second longitudinally extending, laterally spaced, transverse ribs interconnect the opposing margins along their length to seal the overlapping longitudinal seam. The ribs are formed by one or more molten plastic beads extruded onto the film. As a result, a flow regulating passage is defined by the ribs and the opposing margins and a supply passage is defined by the remainder of the film. Water flows from the supply passage to the flow regulating passage through a plurality of longitudinally spaced inlets. Water flows from the flow regulating passage to the exterior of the hose through a plurality of longitudinally spaced outlets longitudinally spaced from the respective inlets to provide a substantial path length from each inlet to a respective outlet. In one embodiment, the outlets each comprise two parallel slits that form between them a flexible flap. The flap serves as an outlet valve, opening and closing as the hose is pressurized and depressurized. However, unless the plastic film is very thick and rigid, the flaps do not close consistently when the hose is depressurized and therefore, the outlets can become clogged by soil drawn into the slits.

A problem encountered in the manufacture of continuous emitter drip irrigation hose is coordinating the position of the outlets and the track pattern of the ribs. If care is not taken, the track pattern of the ribs may overlap the outlets, and thereby cause the outlets to be on the high pressure side of the flow regulating passages.

SUMMARY OF THE INVENTION

One aspect of the invention is a drip irrigation hose of the continuous emitter type in which the outlets from the regulating passage each comprise a single longitudinal slit. By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. The slits are sufficiently long and the film is sufficiently flexible so the water drips from the outlets when the hose is pressurized. The slits are sufficiently short and the film is sufficiently rigid so the outlets close completely when the hose is depressurized.

Another aspect of the invention is a method for making a drip irrigation hose having longitudinal single slit outlets and/or inlets. A first outlet and/or inlet forming wheel has one or more knife blades on its periphery. A second backing wheel engages the first wheel to establish a first nip therebetween. The backing wheel has on its periphery a circumferential slot into which the knife blade fits at the first nip. A third rib forming wheel has around its periphery impressions that define a desired track pattern for the ribs. A second nip is established with a third wheel in which the desired track pattern is formed. The first and second wheels are mounted on a common shaft to operate in synchronism. A continuous strip of plastic film is directed in the following path in the order recited. The film is wrapped around the second wheel to reverse direction and pass into the first nip, thereby forming the outlet slits. The direction of the film is reversed leaving the first nip to transport the film toward the first wheel. The film is wrapped around a portion of the periphery of the first wheel spaced laterally from the knife blade to reverse direction. The direction of the film is reversed to transport the film toward the third wheel. The film is transported under an extruder to deposit a bead of molten plastic on the film before the third wheel. The film is transported into the second nip to form the desired track in the molten plastic. After the film leaves the third wheel, the hose is finished. The described method forms the outlet slits and the track pattern in a coordinated fashion. As a result, the outlets are not restricted or plugged by the ribs.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of specific embodiments of the best mode contemplated of carrying out the invention are illustrated in the drawings, in which:

FIG. 1 is a schematic block diagram of the method for making a drip irrigation hose of the continuous emitter type;

FIG. 2 is a schematic view of a portion of the film path for making a drip irrigation hose in accordance with the invention;

FIG. 3 is a schematic view of a portion of the film path in an alternative embodiment to the film path of FIG. 2; and

FIG. 4 is a side partially cutaway view of a length of drip irrigation hose incorporating the principals of the invention.

FIG. 5 is a schematic diagram of apparatus for completing the manufacture of a drip irrigation hose following the operations shown in FIG. 2.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

The disclosures of U.S. Pat. Nos. 4,247,051, 4,984,739 and 5,123,984 are incorporated fully herein by reference.

The drip irrigation hose of the invention is made from a continuous strip of flexible, water impervious plastic film,

Exhibit: E
Page: 52

generally ranging in thickness between 4 and 15 mil. As depicted by block 10 in FIG. 1, outlets and/or inlets are formed in the strip of film along one margin. As described in more detail below, each outlet and/or inlet comprises a single longitudinal slit in the film. Next, as depicted by block 12, two molten plastic beads made of material compatible with the film are deposited by an extruder on the margin of the film on either side of the outlet slits.

Next, as depicted by block 14, the track pattern of the ribs is formed in the molten beads by a rib forming wheel. The track pattern is repeated each time the rib forming wheel completes a revolution. As depicted by block 16, after the ribs are formed, the margins of the film are overlapped to position between them the track pattern. Finally, as depicted by block 18, the overlapping margins are sealed by the still molten ribs to form the finished hose. The described steps, except for formation of the outlets and/or inlets, are shown in more detail in the referenced '984 patent. Alternatively, either the inlets or the outlets could be formed as interruptions in one of the ribs.

FIG. 2 illustrates the path of a continuous strip of film 38 from which the drip irrigation hose is made between the formation of the outlets and/or inlets (block 10) and the formation of the track pattern (block 14). An outlet forming wheel 20 and a rib forming wheel 22 are mounted on a common shaft 24 to synchronize their operation. Wheels 20 and 22 have the same diameter. A backing wheel 26 engages outlet forming wheel 20 to establish a nip 28 therebetween. A knife blade 30 is mounted on the periphery of wheel 20. Wheel 26 has a circumferential slot 32 into which knife blade 30 fits at nip 28. Direction changing wheels 34 and 36 also define part of the film path. Wheels 20, 22, 26, 34, and 36 have flanges to guide film 38 laterally during the manufacturing operation.

Wheel 22 has, around its periphery, impressions that define the desired track pattern 24, for example, one of the track patterns shown in the '051 patent or in the '739 patent. The direction of movement of film 38 is depicted by the arrows in FIG. 2. Film 38 is wrapped around wheel 26 to reverse direction and pass into nip 28. As a result, a slit is formed in film 38 each time blade 30 passes into nip 28. A slit is formed each time wheel 20 completes one revolution. After leaving wheel 26, film 38 is wrapped around wheel 34 to reverse direction and return toward wheel 20. Film 38 is wrapped around a portion of the periphery of wheel 20, spaced laterally from knife blade 30, to reverse direction. After leaving wheel 20, film 38 is wrapped around wheel 36 to reverse direction and move toward wheel 22. Wheel 36 could be canted slightly to provide a smooth transition in the film path between wheels 20 and 22, and the film could twist slightly between wheels 36 and 22. Between wheels 36 and 22, film 38 passes under an extruder 40 which deposits one or more molten plastic beads on one margin of film 38. Since wheels 20 and 22 are mounted on a common shaft, the formation of the outlets and the track pattern is coordinated and their relative positioning is closely controlled. After leaving wheel 22, film 38 is finished in the manner illustrated in FIG. 5. More specifically, as film 38 approaches extruder 40, its inner margin is folded over and extruder 40 forms one or more beads 42 on the exposed surface of the inner margin of film 38. A backing wheel 60 underlies wheel 22, which has track pattern 24. After passage through the nip formed by wheels 22 and 60, the outer margin of film 38 is folded by a guide 62 to overlap the inner margin of film 38. The folded film 38 then passes through the nip of a form wheel 64 and a backing wheel 66. Form wheel 64 has a groove 68 that depresses the beads to set the bead height at a specified value. The value of the bead height determines the flow rate of the hose. A finished hose 70 leaves the nip between wheels 66 and 68. In a typical embodiment, the diameters of wheels 20 and 22 would be about from 3 to 6 inches, the diameter of wheel 26 would be about 4 inches, the diameters of wheels 34 and 36 would be about 4 inches, and the distance between wheels 22 and 36 would be about 24 inches.

If the inlets also comprise slits another knife blade is mounted on the periphery of wheel 20 laterally spaced from knife blade 30 and wheel 26 has another circumferential slot laterally spaced from slot 32 into which the other knife blade fits. The inlets as well as the outlets are formed as the respective knife blades pass into nip 28.

FIG. 3 illustrates an alternative film path arrangement that permits wheels 20 and 22 to have different diameters so that the outlet spacing can be greater than the track pattern length, which produces a skip in the outlet configuration. Wheel 20 and a toothed wheel 50 are mounted on a shaft 52. Wheel 22 and a toothed wheel 54 are mounted on a shaft 56. A toothed belt 58 couples wheels 50 and 54 to synchronize the rotation of wheels 20 and 22 in a ratio to cause the desired skip in the outlet spacing relative to the track pattern length. In short toothed wheels 50 and 54 and toothed belt 58 replace shaft 24 in the embodiment of FIG. 2. The diameters of wheels 20, 22, 50, and 54 are selected so the angular velocity of wheel 22 is a multiple of the angular velocity of wheel 20, depending upon the desired outlet skip. As a result, the same rib forming wheel 22 can be used to produce a variety of outlet spacings, i.e., skipped outlet configurations.

In FIG. 4, the completed drip irrigation hose is shown. Strip 38 is bent along its length to form an overlapping longitudinal seam between an interior margin and an exterior margin of the strip. Spaced apart, transverse ribs 42 and 43 extend longitudinally through the seam to connect the margins of strip 38, forming a seal and a flow regulating passage 44 therebetween. A water supply passage 45, having a much larger cross-section area than flow regulating passage 44 is defined by the remainder of strip 38. Longitudinally spaced apart slits 46 in the portion of strip 38 between supply passage 45 and flow regulating passage 44 serve as inlets to flow regulating passage 44. Longitudinally spaced apart slits 47, formed in the exterior margin of strip 38, serve as outlets from the hose. Slits 47 are displaced from the respective slits 46 to provide a substantial path length from each inlet to a respective outlet. Preferably, cross ribs 48 are employed to divide the flow regulating passage into segments, such that slit 46 is at one end of the segment and a slit 47 is at the other end of a segment. Alternatively, the inlets could be formed by interruptions in rib 42 as illustrated in FIGS. 5 and 6 of the '051 patent and as illustrated in the '739 patent. The shape of ribs 42, 43 and 48 are determined by the track pattern on wheel 22 (FIG. 2). Preferably, chevrons are formed on the adjacent interior surfaces of ribs 42 and 43 to create turbulent flow in the flow regulating passage as illustrated in the '739 patent.

By controlling the length of the slits and the flexibility of the film, water drips from the outlets when the hose is pressurized without clogging when the hose is depressurized. Typically, the line pressure of the water used for crop irrigation ranges from about 4 psig to 14 psig. Slits 47 are sufficiently long and strip 38 is sufficiently flexible so the water drips from the outlets when the hose is pressurized, rather than squirting. The effective area of the outlets remains small because the material on both sides of the slits remain in the same plane, rather than buckling. If the slits are

Exhibit: E

Page: 53

too short or the strip is too rigid, the material on either side of the slits does not move sufficiently to make a large hole when the hose is pressurized and water squirts out the hose and erodes the soil. Slits **47** are sufficient short and strip **38** is sufficiently rigid so the outlets close completely when the hose is depressurized. If the slits are too long or the strip is too flexible, the slits do not close when the hose is depressurized. Typically, the slits are about ¼ inch for a 4 mil film thickness and the slits are about ⅜ inch for a 15 mil film thickness. Thus, if the slits are much shorter than about ¼ inch for a 4 mil film thickness or if the film is much thicker than about 4 mil for a slit length of about ¼ inch, the water may squirt from the outlets. Similarly, if the slits are much longer than about ⅜ inch for a 15 mil film thickness or if the film is much thinner than about 15 mil for a slit length of about ⅜ inch, the outlets may not close after the hose is depressurized.

Despite the foregoing, it has recently been discovered that with a slit length of almost one inch, the outlets still close after the hose is depressurized if the film is flexible enough.

The described embodiment of the invention is only considered to be preferred and illustrative of the inventive concept; the scope of the invention is not to be restricted to such embodiments. Various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of this invention.

What is claimed is:

1. A method for making drip irrigation hose comprising:

rotating an outlet forming wheel having a knife blade on its periphery;

positioning a backing wheel to engage the outlet forming wheel and establish a nip, the backing wheel having a circumferential slot into which the knife blade fits as the outlet forming wheel rotates;

moving a strip of plastic film through the nip to form single slit outlets repeatedly along the strip as the knife blade rotates;

forming on the strip an elongated flow regulating passage; and

forming inlets to the flow regulating passage that are spaced from the outlets to form a substantial path length from each inlet to a corresponding outlet, wherein the outlets couple the flow regulating passage to the exterior of the hose.

2. The method of claim 1, wherein the strip of plastic film has first and second margins, and wherein the method further comprises overlapping and sealing the first and second margins to form a tube from the strip of plastic film.

3. The method of claim 2, wherein the flow regulating passage lies between the overlapping margins.

4. The method of claim 1, wherein the step of forming a flow regulating passage overlaps and seals margins of the strip between the inlets and the outlets, wherein the outlets couple the flow regulating passage to the exterior of the hose.

5. The method of claim 1, in which the outlet forming wheel is rotated such that the knife blade forms slits that close completely when the hose is depressurized.

6. The method of claim 5, in which the strip is flexible, additionally comprising partially wrapping the strip around one of the wheels as the strip moves through the nip.

7. The method of claim 1, in which the strip is flexible, additionally comprising partially wrapping the strip around one of the wheels as the strip moves through the nip.

* * * * *

Exhibit: E

Page: 54